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DC POWER SUPPLY

LVR SERIES

MODEL 6267B

H/P Part No. 06267-90002

OPERATING AND SERVICE MANUAL

FOR SERIALS 8G0301 - up*

*For Serials Above 8G0301
Check for inclusion of
change page.

*For Serials Below 8G0301
Refer to Appendix A

100 Locust Avenue, Berkeley Heights, New Jersey 07922

HP Part No. 06267-90002

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SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 This power supply, see cover, is completely transistorized and suitable for either bench or relay rack operation. It is a well-regulated, Constant Voltage/Constant Current supply that will furnish full rated output voltage at the maximum rated output current or can be continuously adjusted throughout the output range. The front panel CURRENT control can be used to establish the output current limit (overload or short circuit) when the supply is used as a constant voltage source and the VOLTAGE controls can be used to establish the voltage limit (ceiling) when the supply is used as a constant current source. The supply will automatically crossover from constant voltage to constant current operation and vice versa if the output current or voltage exceeds these preset limits.

1-3 The power supply contains an added feature for protection of delicate loads. A limit can be set on the output voltage. If this limit is exceeded the output will automatically be shorted.

1-4 The power supply has both front and rear terminals. Either the positive or negative output terminal may be grounded or the power supply can be operated floating at up to a maximum of 300 Volts off ground.

1-5 Output voltage and current are continuously monitored on the two front panel meters.

1-6 Terminals located at the rear of the unit allow access to various control points within the unit to expand the operating capabilities of the power supply. A brief description of these capabilities is given below:

a. Remote Programming. The power supply output voltage or current may be programmed (controlled) from a remote location by means of an external voltage source or resistance.

b. Remote Sensing. The degradation in regulation which occurs at the load because of the voltage drop in the load leads can be reduced by using the power supply in the remote sensing mode of operation.

c. Series and Auto-Series Operation. Power supplies may be used in series when a higher output voltage is required in the constant voltage mode of operation or when greater voltage compliance is required in the constant current mode of operation. Auto-Series operation permits one knob control of the total output voltage from a "master" supply.

d. Parallel and Auto-Parallel Operation. The power supply may be operated in parallel with a similar unit when greater output current capability is required. Auto-Parallel operation permits one knob control of the total output current from a "master" supply.

e. Auto-Tracking. The power supply may be used as a "master" supply, having control over one (or more) "slave" supplies that furnish various voltages for a system.

1-7 SPECIFICATIONS

1-8 Detailed specifications for the power supply are given in Table 1-1.

1-9 OPTIONS

1-10 Options are factory modifications of a standard instrument that are requested by the customer. The following options are available for the instrument covered by this manual. Where necessary, detailed coverage of the options is included throughout the manual.

Option No.	Description
05	50Hz Regulator Realignment: Standard instruments will operate satisfactorily at both 60 and 50Hz without adjustment. However, Option 05 factory realignment results in more efficient operation at 50Hz, and is recommended for all applications when continuous operation from a 50Hz ac input is intended. Two resistors are needed.
07	Ten-Turn Output Voltage Control: A single control that replaces both coarse and fine voltage controls and improves output settability. One pot is required.
08	Ten-Turn Output Current Control: A single control that replaces both coarse and fine current controls and improves settability. One pot is required.
09	Ten-Turn Output Voltage and Current Control: Options 07 and 08 on same instrument.
10	Chassis Slides: Enables convenient access to power supply interior for maintenance purposes.

Option No.	Description
13	Three Digit Graduated Decadial Voltage Control: Control that replaces coarse and fine voltage controls permitting accurate resettability.
14	Three Digit Graduated Decadial Current Control: Control that replaces coarse and fine current controls permitting accurate resettability.
27	Rewire for 208Vac Input: Consists of reconnecting the input transformers for 208 Volt operation and changing the fuses.
28	Rewire for 230Vac Input: Consists of reconnecting the input transformers for 230 Volt operation and changing the fuses.

1-11 INSTRUMENT/MANUAL IDENTIFICATION

1-12 Hewlett-Packard power supplies are identified by a three-part serial number tag. The first part is the power supply model number. The second part is the serial number prefix, which consists of a number-letter combination that denotes the date of a significant design change. The number designates the year, and the letter A through M designates the month, January through December, respectively, with "I" omitted. The third part is the power supply serial number; a different sequential number is assigned to each power supply.

1-13 If the serial number on your instrument does not agree with those on the title page of the manual, Change Sheets supplied with the manual or Manual Backdating Changes in Appendix A define the differences between your instrument and the instrument described by this manual.

1-14 ORDERING ADDITIONAL MANUALS

1-15 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and hp part number provided on the title page.

Table 1-1. Specifications

INPUT:
115Vac ±10%, single phase, 57-63Hz, 8A 550W @ 115V.

OUTPUT:
0-40 Volts @ 0-10 Amperes.

LOAD REGULATION:
Constant Voltage - Less than 0.01% plus 200μV for a load current change equal to the current rating of the supply.
Constant Current - Less than 0.02% plus 500μA for a load voltage change equal to the voltage rating of the supply.

LINE REGULATION:
Constant Voltage - Less than 0.01% plus 200μV for a change in line voltage from 103.5 to 126.5 at any output voltage and current within rating.
Constant Current - Less than 0.02% plus 500μA for a line voltage change from 103.5 to 126.5 at any output voltage and current within rating.

RIPPLE AND NOISE:
Constant Voltage - Less than 200μVrms, 10mV p-p (dc to 20MHz).
Constant Current - Less than 3mArms.

TEMPERATURE RANGES:
Operating: 0 to 55°C. Storage: -40 to +75°C.

TEMPERATURE COEFFICIENT:
Constant Voltage - Less than 0.01% plus 200μV change per degree centigrade change in ambient following 30 minutes warm-up.
Constant Current - Less than 0.01% plus 1mA change per degree centigrade change in ambient following 30 minutes warm-up.

STABILITY:
Constant Voltage - Less than 0.03% plus 500μV total drift for 8 hours following 30 minutes warm-up under constant ambient conditions.
Constant Current - Less than 0.03% plus 3mA total drift for 8 hours following 30 minutes warm-up under constant ambient conditions.

OUTPUT IMPEDANCE:
0.1 milliohm in series with 1 μhenry.

RADIO FREQUENCY INTERFERENCE:
Free from conducted and radiated RFI to the extent that the unit meets all the requirements of MIL-I-6181D.

TRANSIENT RECOVERY TIME:
Less than 50μsec is required for output voltage recovery (in constant voltage operation) to within 10mV of the nominal output voltage following a 5 Ampere change in output current.

METERS:
Front panel voltmeter (0-50V) and ammeter (0-12A) are provided. (Accurate within 2%.)

OUTPUT CONTROLS:
Single-turn coarse and fine voltage and current controls are included on the front panel.

OUTPUT TERMINALS:
An output terminal strip is located on the rear of the chassis. All power supply terminals are isolated from the chassis and either the positive or negative terminal may be connected to the chassis through a separate ground terminal located adjacent to the output terminals. Front panel, banana jack type, output terminals are included and are limited to 3 Amperes maximum current output.

REMOTE VOLTAGE PROGRAMMING:
Constant Voltage - 1V/Volt (Accuracy: 1%).
Constant Current - 50mV/Amp (Accuracy: 10%).

REMOTE RESISTANCE PROGRAMMING:
Constant Voltage - 200 ohms/Volt. All programming terminals on rear barrier strips.
Constant Current - 100 ohms/Ampere. All programming terminals on rear barrier strips.

OVERVOLTAGE PROTECTION "CROWBAR":
The minimum crowbar trip setting above the desired operating output voltage to prevent false crowbar tripping is 7% of output voltage setting plus 1 Volt. Range is 2.5 to 45Vdc.

COOLING:
Convection cooling is employed. The supply has no moving parts.

SIZE:
$5\frac{1}{4}$" (14cm) H x $17\frac{1}{2}$" (44,4cm) D x 19" (48,3cm) W. The unit can be mounted in a standard 19" rack panel.

WEIGHT:
42 lbs. (19,1 kg.) net. 57 lbs. (25,9 kg.) shipping.

FINISH: Light gray panel with dark gray case.

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, file a claim with the carrier immediately. Hewlett-Packard Sales and Service office should be notified.

2-3 MECHANICAL CHECK

2-4 This check should confirm that there are no broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches, and that the meter is not scratched or cracked.

2-5 ELECTRICAL CHECK

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. It is necessary only to connect the instrument to a source of power and it is ready for operation.

2-9 LOCATION

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the rear of the instrument when it is in operation. It should be used in an area where the ambient temperature does not exceed 55°C.

2-11 OUTLINE DIAGRAM

2-12 Figure 2-1 illustrates the outline shape and dimensions of Models 6256B, 6264B, and 6267B.

2-13 RACK MOUNTING

2-14 This instrument is full rack size and can be easily rack mounted in a conventional 19 inch rack panel using standard mounting screws.

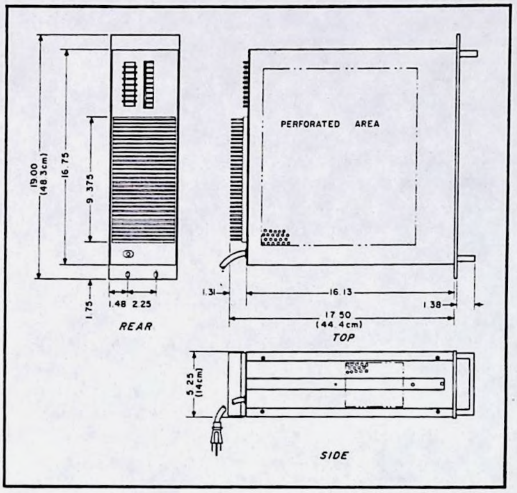


Figure 2-1. Outline Diagram

2-15 INPUT POWER REQUIREMENTS

2-16 This power supply may be operated continuously from either a nominal 115 Volt, 208 Volt, or 230 Volt 57-63Hz power source. The unit as shipped from the factory is wired for 115 Volt operation. The input power required when operated from a 115 Volt power source at full load is:

Model	Input Current	Input Power
6256B	5A	375W
6264B	8A	600W
6267B	8A	550W

2-17 CONNECTIONS FOR 208 VOLT OPERATION (Figure 2-2B)

2-18 Normally, the primary windings of the input transformers T1 and T2 are connected in parallel for operation from a 115V source. To convert the power supply to operation from a 208 Volt source, the input transformers T1 and T2 are connected in series as follows:

a. Unplug line cord and remove top cover.

b. Remove jumpers between taps 1 and 3, 2 and 5. Solder jumpers between taps 2 and 3 (see Figure 2-2B).

c. Disconnect input lead to tap 5 and connect it, instead, to tap 4.

d. Replace fuses F1 and F2 with 3A, 230V fuses.

2-19 CONNECTIONS FOR 230 VOLT OPERATION (Figure 2-2C)

2-20 To convert the power supply to operation from a 230 Volt source, the input transformers windings are connected in series as follows:

a. Unplug the line cord and remove the top covers.

b. Remove the jumpers between taps 1 and 3, 2 and 5. Solder a jumper between taps 3 and 2 on the input power transformers T1 and T2, see Figure 2-2C.

c. Replace existing fuse with a 3 Ampere, 230 Volt fuse.

2-21 CONNECTIONS FOR 50HZ OPERATION

2-22 For 50Hz operation R76 must be replaced with a 150KΩ resistor as specified in Table 6-4 under Option 05. R78 must also be replaced with a 270Ω resistor. After these replacements it may be necessary to adjust R75 in order to get the proper voltage drop across the series regulator. Ripple imbalance should be checked and corrected as described in Paragraph 5-82.

2-23 POWER CABLE

2-24 To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three conductor power cable. The third conductor is the ground conductor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable three-prong connector is the ground connection.

2-25 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to ground.

2-26 REPACKAGING FOR SHIPMENT

2-27 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

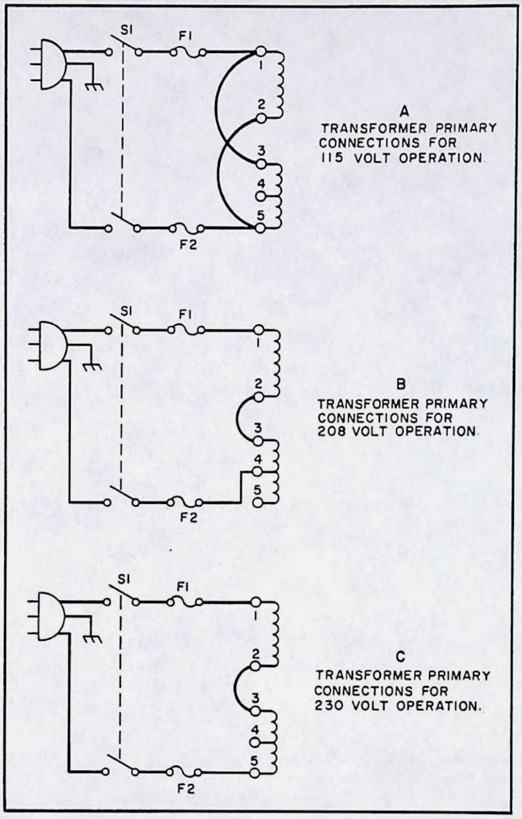


Figure 2-2. Primary Connections for 208Vac and 230Vac Operation

SECTION III
OPERATING INSTRUCTIONS

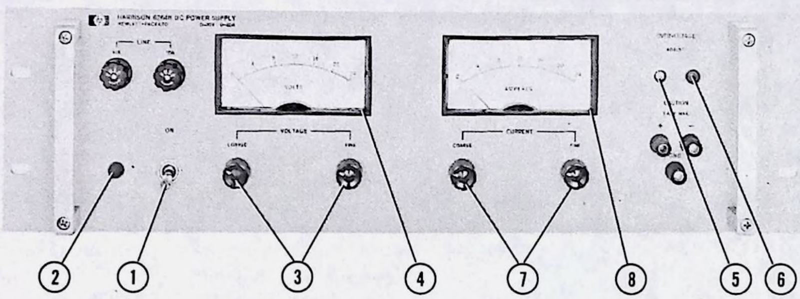


Figure 3-1. Front Panel Controls and Indicators

3-1 TURN-ON CHECKOUT PROCEDURE

3-2 The following checkout procedure describes the use of the front panel controls and indicators and ensures that the supply is operational.

a. Set ON/off switch (1) to ON, and observe that pilot lamp (2) lights.

b. Adjust VOLTAGE controls (3) until desired voltage is indicated on voltmeter (4).

c. To ensure that overvoltage "crowbar" circuit is operational, rotate OVERVOLTAGE ADJUST control (5) (screwdriver adjust) counterclockwise until unit "crowbars". Overvoltage lamp (6) will light and output voltage will fall to zero Volts.

d. To deactivate "crowbar", return OVERVOLTAGE ADJUST control to its maximum clockwise position and turn off supply. Turn supply back on and voltage should again be value obtained in step b.

e. To check out constant current circuit, turn off supply. Short circuit rear output terminals and turn on supply.

f. Adjust CURRENT controls (7) until desired output current is indicated on ammeter (8).

g. Remove short and read following paragraphs before connecting actual load to supply.

3-3 OPERATING MODES

3-4 The power supply is designed so that its mode of operation can be selected by making strapping connections between particular terminals on the terminal strip at the rear of the power supply. The terminal designations are stenciled in white on the power supply above their respective terminals. The following paragraphs describe the procedures for utilizing the various operational capabilities of the power supply. A more theoretical description concerning the operational features of this supply is contained in Application Note 90, Power Supply Handbook; available at no charge from your local Hewlett-Packard sales office. Sales office addresses appear at the rear of the manual.

3-5 NORMAL OPERATING MODE

3-6 The power supply is normally shipped with its rear terminal strapping connections arranged for Constant Voltage/Constant Current, local sensing, local programming, single unit mode of operation. This strapping pattern is illustrated in Figure 3-2. The operator selects either a constant

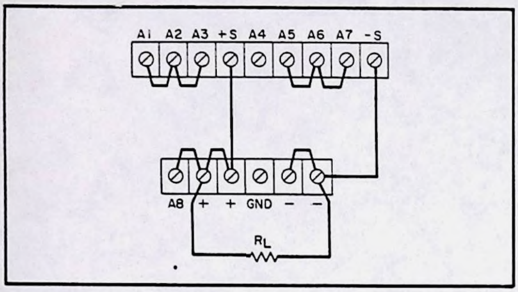


Figure 3-2. Normal Strapping Pattern

voltage or a constant current output using the front panel controls (local programming, no strapping changes are necessary).

3-7 CONSTANT VOLTAGE

3-8 To select a constant voltage output, proceed as follows:

a. Turn-on power supply and adjust VOLTAGE control for desired output voltage (output terminals open).

b. Short output terminals and adjust CURRENT controls for maximum output current allowable (current limit), as determined by load conditions. If a load change causes the current limit to be exceeded, the power supply will automatically crossover to constant current output at the preset current limit and the output voltage will drop proportionately. In setting the current limit, allowance must be made for high peak current which can cause unwanted cross-over. (Refer to Paragraph 3-56.)

3-9 CONSTANT CURRENT

3-10 To select a constant current output, proceed as follows:

a. Short output terminals and adjust CURRENT controls for desired output current.

b. Open output terminals and adjust VOLTAGE controls for maximum output voltage allowable (voltage limit), as determined by load conditions. If a load change causes the voltage limit to be exceeded, the power supply will automatically crossover to constant voltage output at the preset voltage limit and the output current will drop proportionately. In setting the voltage limit, allowance must be made for high peak voltages which can cause unwanted crossover. (Refer to Paragraph 3-59.)

3-11 OVERVOLTAGE TRIP POINT ADJUSTMENT

3-12 The crowbar trip voltage can be adjusted by using the screwdriver control on the front panel. The trip voltage range is as follows:

6256B	6264B	6267B
2 to 12Vdc	2.5 to 23Vdc	2.5 to 45Vdc

When the crowbar trips, the output is shorted and the amber indicator on the front panel lights. Clockwise rotation of the control produces higher trip voltages. The factory sets the control fully clockwise.

3-13 False crowbar tripping must be considered when adjusting the trip point. If the trip voltage is adjusted too close to the operating output voltage of the supply, a transient in the output will falsely trip the crowbar. It is recommended that the crowbar be set higher than the output voltage by 7% of the output voltage plus one Volt. (Refer to Paragraph 5-86.)

3-14 CONNECTING LOAD

3-15 Each load should be connected to the power supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the power supply. Each pair of connecting wires should be as short as possible and twisted or shielded to reduce noise pickup. (If shield is used, connect one end to ground and leave the other end unconnected.)

3-16 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals via a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. For this case, remote sensing should be used (Paragraph 3-38).

3-17 Positive or negative voltages can be obtained from this supply by grounding either one of the output terminals or one end of the load. Always run both leads to the load, regardless of where the set-up is grounded. This will eliminate any possibility of output current return paths through the power source ground which would damage the line cord plug. This supply can also be operated up to 300V dc off ground, if neither output terminal is grounded.

3-18 OPERATION OF SUPPLY BEYOND RATED OUTPUT

3-19 The shaded area on the front panel meter face indicates the amount of output voltage or current that is available in excess of the normal rated output. Although the supply can be operated in this shaded region without being damaged, it cannot be guaranteed to meet all of its performance specifications. However, if the line voltage is maintained above its nominal value, the supply will probably operate within specifications.

3-20 FRONT PANEL OUTPUT TERMINALS

3-21 The output posts on the front panel cannot be used in any application where the output current might exceed 3 Amperes. Current in excess of this value will damage the connecting wires inside the supply.

3-22 OPTIONAL OPERATING MODES

3-23 REMOTE PROGRAMMING, CONSTANT VOLTAGE

3-24 The constant voltage output of the power supply can be programmed (controlled) from a remote location if required. Either a resistance or voltage source can be used for the programming device. The wires connecting the programming terminals of the supply to the remote programming device should be twisted or shielded to reduce noise pickup. The VOLTAGE controls on the front panel are disabled in the following procedures.

3-25 Resistance Programming (Figure 3-3). In this mode, the output voltage will vary at a rate determined by the programming coefficient (200 ohms per Volt). The output voltage will increase 1 Volt for each 200 ohms added in series with the programming terminals. The programming coefficient is determined by the programming current. This current is factory adjusted to within 1% of 5mA. If greater programming accuracy is required, it may be achieved by changing resistor R13 as discussed in Paragraph 5-76.

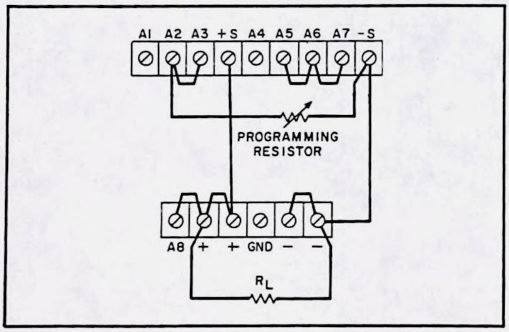


Figure 3-3. Remote Resistance Programming (Constant Voltage)

3-26 The output voltage of the power supply should be zero ±10 millivolts when zero ohms is connected across the programming terminals. If a zero ohm voltage closer than this is required, it may be achieved by changing resistor R6 or R8 as described in Paragraph 5-75.

3-27 To maintain the stability and temperature coefficient of the power supply, use programming resistors that have stable, low noise, and low temperature (less than 30ppm per degree Centigrade) characteristics. A switch can be used in conjunction with various resistance values in order to obtain discrete output voltages. The switch should have make-before-break contacts to avoid momentarily opening the programming terminals during the switching interval.

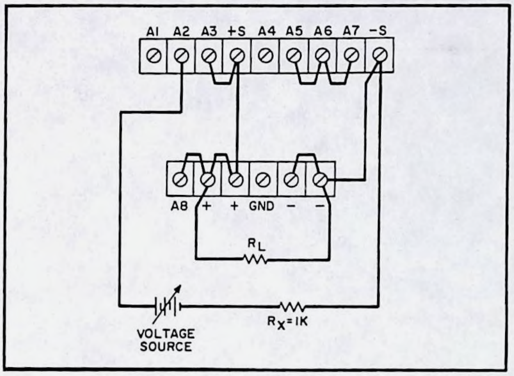


Figure 3-4. Remote Voltage Programming (Constant Voltage)

3-28 Voltage Programming (Figure 3-4). Employ the strapping pattern shown on Figure 3-4 for voltage programming. In this mode, the output voltage will vary in a 1 to 1 ratio with the programming voltage (reference voltage) and the load on the programming voltage source will not exceed 20 microamperes. Impedance matching resistor (R_X) is required to maintain the temperature coefficient and stability specifications of the supply.

3-29 Methods of voltage programming with gain are discussed in Application Note 90, Power Supply Handbook; available at no charge from your local Hewlett-Packard sales office.

3-30 REMOTE PROGRAMMING, CONSTANT CURRENT

3-31 Either a resistance or a voltage source can be used to control the constant current output of the supply. The CURRENT controls on the front panel are disabled according to the following procedures.

3-32 Resistance Programming (Figure 3-5). In this mode, the output current varies at a rate determined by the programming coefficient as follows:

Model	Programming Coefficient
6256B	10 ohms/Amp
6264B	10 ohms/Amp
6267B	100 ohms/Amp

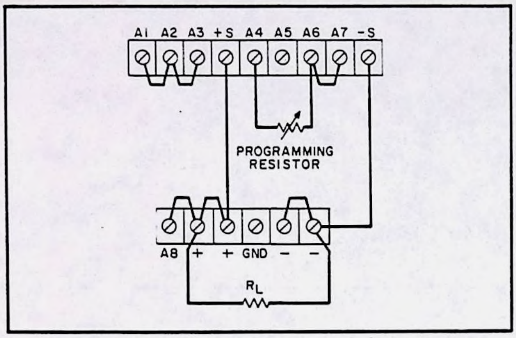


Figure 3-5. Remote Resistance Programming (Constant Current)

The programming coefficient is determined by the Constant Current programming current which is adjusted to within 10% of 2.5mA at the factory. If greater programming accuracy is required, it may be achieved by changing resistor R19 as outlined in Paragraph 5-79.

3-33 Use stable, low noise, low temperature coefficient (less than 30ppm/°C) programming resistors to maintain the power supply temperature coefficient and stability specifications. A switch may be used to set discrete values of output current. A make-before-break type of switch should be used since the output current will exceed the maximum rating of the power supply if the switch contacts open during the switching interval.

CAUTION

If the programming terminals (A4 and A6) should open at any time during this mode, the output current will rise to a value that may damage the power supply and/or the load. To avoid this possibility, connect a 200 ohm resistor for 6256B and 6264B, and a 1K ohm resistor for 6267B across the programming terminals. Like the programming resistor, this resistor should be of the low noise, low temperature coefficient type.

3-34 Voltage Programming (Figure 3-6). In this mode, the output current will vary linearly with changes in the programming voltage. The programming voltage should not exceed 0.7 Volts. Voltage in excess of 0.7 Volts will result in excessive power dissipation in the instrument and possible damage.

3-35 The output current varies at a rate determined by the programming coefficient as follows:

Model	Programming Coefficient
6256B	25mV/Amp
6264B	25mV/Amp
6267B	50mV/Amp

The current required from the voltage source will be less than 20μA. Impedance matching resistor R_X is required to maintain the temperature coefficient and stability specifications of the supply.

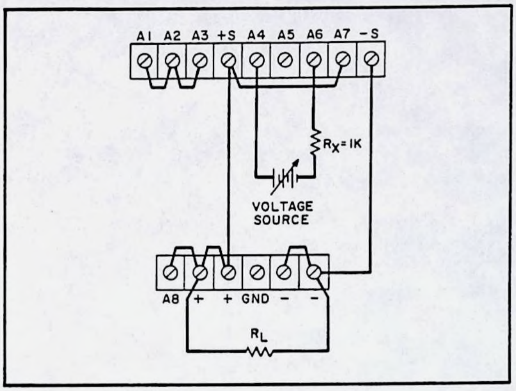


Figure 3-6. Remote Voltage Programming (Constant Current)

3-36 Methods used to voltage program a power supply with gain are discussed in Application Note 90, Power Supply Handbook; available at no charge from your local hp Sales Office.

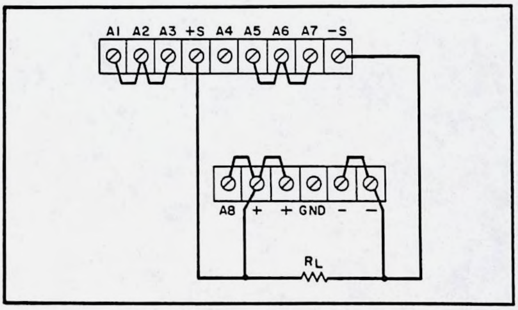


Figure 3-7. Remote Sensing

3-37 REMOTE SENSING (See Figure 3-7)

3-38 Remote sensing is used to maintain good regulation at the load and reduce the degradation of regulation which would occur due to the voltage drop in the leads between the power supply and the load. Remote sensing is accomplished by utilizing the strapping pattern shown in Figure 3-7. The power supply should be turned off before changing strapping patterns. The leads from the

sensing (±S) terminals to the load will carry much less current than the load leads and it is not required that these leads be as heavy as the load leads. However, they must be twisted or shielded to minimize noise pickup.

3-39 Note that it is desirable to minimize the drop in the load leads and it is recommended that the drop not exceed 1 Volt per lead if the power supply is to meet its dc specifications. If a larger drop must be tolerated, please consult a hp sales engineer.

NOTE

> Due to the voltage drop in the load leads, it may be necessary to readjust the current limit in the remote sensing mode.

3-40 The procedure just described will result in a low dc output impedance at the load. If a low ac impedance is required, it is recommended that the following precautions be taken:

a. Disconnect output capacitor C 20.

b. Connect a capacitor having similar characteristics (approximately same capacitance, same voltage rating or greater, and having good high frequency characteristics) across the load using short leads.

3-41 Although the strapping patterns shown in Figures 3-3 through 3-6 employ local sensing, note that it is possible to operate a power supply simultaneously in the remote sensing and Constant Voltage/Constant Current remote programming modes.

3-42 AUTO-PARALLEL OPERATION (Figure 3-8)

3-43 Two or more power supplies can be connected in an Auto-Parallel arrangement to obtain an output current greater than that available from one supply. Auto-Parallel operation permits equal current sharing under all load conditions, and allows complete control of the output current from one master power supply. The output current of each slave will be approximately equal to the master's regardless of the load conditions. Because the output current controls of each slave are operative, they should be set to maximum to avoid having the slave revert to constant current operation; this would occur if the master output current setting exceeded the slave's.

3-44 Additional slave supplies may be added in parallel to the Master/Slave combination. All the connections between the Master and Slave #1 are duplicated between Slave #1 and the added Slave supply. In addition, the strapping pattern of the added Slave should be the same as Slave #1.

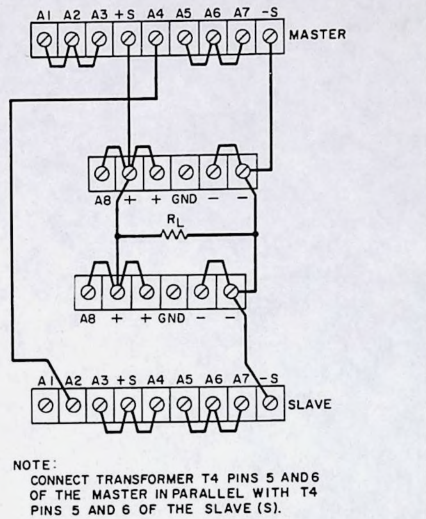
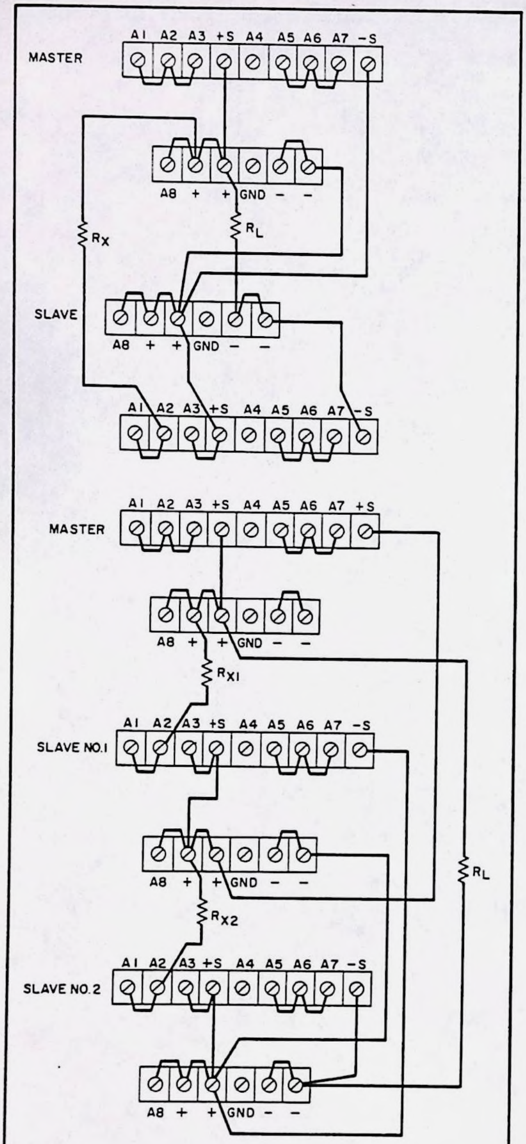


Figure 3-8. Auto-Parallel Operation, Two Units

3-45 Overvoltage protection is controlled by the crowbar circuit in the master supply which monitors the voltage across the load and fires the SCR's in both units if an overvoltage condition occurs. The firing pulses are fed to the slave supply from T4, winding 5-6 of the Master. The overvoltage trip point is adjusted on the master supply. The overvoltage adjust potentiometer on the slave supply should be set to maximum (CW) so that the Master crowbar will control the Slave.

3-46 AUTO-SERIES OPERATION (Figure 3-9)

3-47 Two or more power supplies can be operated in Auto-Series to obtain a higher voltage than that available from a single supply. When this connection is used, the output voltage of each slave supply varies in accordance with that of the master supply. At maximum output voltage, the voltage of the slaves is determined by the setting of the front panel VOLTAGE control on the master. The master supply must be the most positive supply of the series. The output CURRENT controls of all series units are operative and the current limit is equal to the lowest control setting. If any output CURRENT controls are set too low, automatic crossover to constant current operation will occur and the output voltage will drop. Remote sensing and programming can be used; however, the strapping arrangements shown in Figure 3-9 show local sensing and programming.



NOTE:
CONNECT TRANSFORMER T4 PINS 5 AND 6 OF THE MASTE IN PARALLEL WITH T4 PINS 5 AND 6 OF THE SLAVE(S).

Figure 3-9. Auto-Series Operation, Two and Three Units

3-48 In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors (R_X) shown in Figure 3-9 should be stable, low noise, low temperature coefficient (less than 30ppm per degree Centigrade) resistors. The value of each resistor is dependent on the maximum voltage rating of the "master" supply. The value of R_X is this voltage divided by the voltage programming current of the slave supply ($1/K_P$ where K_P is the voltage programming coefficient). The voltage contribution of the slave is determined by its voltage control setting.

3-49 Overvoltage protection is provided in Auto-Series operation. The overvoltage potentiometer in each supply is adjusted so that it trips at a point slightly above the output voltage that it will contribute.

3-50 AUTO-TRACKING OPERATION (Figure 3-10)

3-51 The Auto-Tracking configuration is used when it is necessary that several different voltages referred to a common bus, vary in proportion to the setting of a particular instrument (the control or master). A fraction of the master's output voltage is fed to the comparison amplifier of the slave supply, thus controlling the slave's output. The master must have the largest output voltage of any power supply in the group (must be the most positive supply in the example shown on Figure 3-10).

3-52 The output voltage of the slave is a percentage of the master's output voltage, and is determined by the voltage divider consisting of R_X and the voltage control of the slave supply, R_P where $E_S = E_M(R_P/R_X + R_P)$. Turn-on and turn-off of the power supplies is controlled by the master. Remote sensing and programming can be used; although the strapping patterns for these modes show only local sensing and programming. In order to maintain the temperature coefficient and stability specifications of the power supply, the external resistors should be stable, low noise, low temperature coefficient (less than 30ppm per $^{\circ}C$) resistors.

3-53 The overvoltage protection circuit in each unit is operable and independently monitors the voltage across its own load. Notice that if the master supply crowbars, the output voltage of each slave will also decrease. However, the reverse is not true. If one of the slave units crowbars, the other supplies in the ensemble will not be affected.

3-54 SPECIAL OPERATING CONSIDERATIONS

3-55 PULSE LOADING

3-56 The power supply will automatically cross over from constant voltage to constant current operation, or the reverse, in response to an increase (over the preset limit) in the output current or voltage, respectively. Although the preset limit may be set higher than the average output current

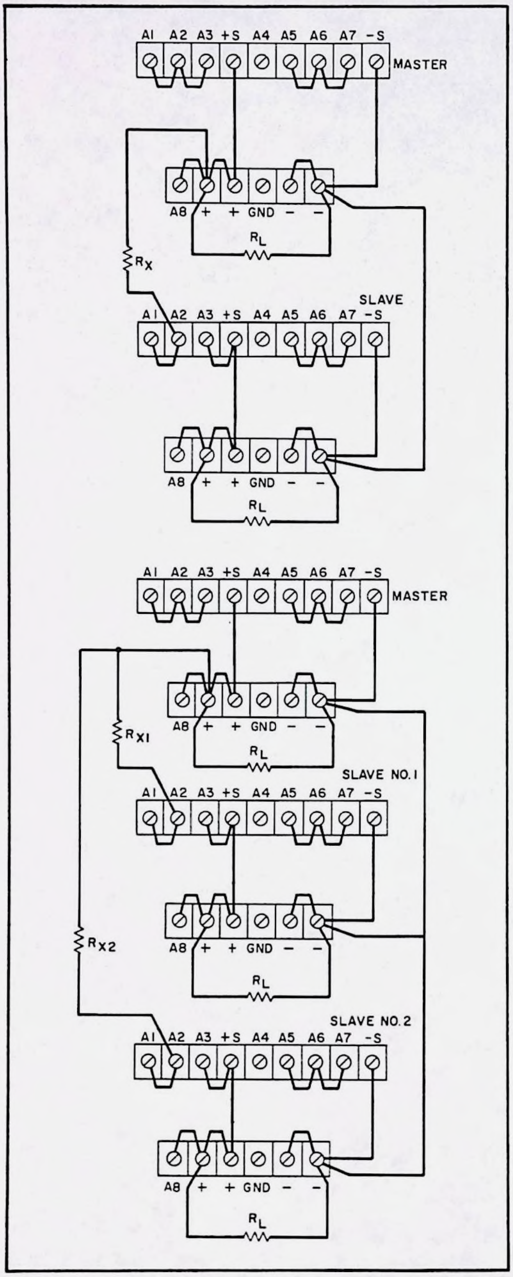


Figure 3-10. Auto-Tracking, Two and Three Units

or voltage, high peak currents or voltages (as occur in pulse loading) may exceed the preset limit and cause crossover to occur. If this crossover limiting is not desired, set the preset limit for the peak requirement and not the average.

3-57 OUTPUT CAPACITANCE

3-58 An internal capacitor (C20) connected across the output terminals of the power supply, helps to supply high-current pulses of short duration during constant voltage operation. To reduce current surges, this capacitor can be removed by unstrapping terminal A8.

3-59 The effects of the output capacitor during constant current operation are as follows:

a. The output impedance of the power supply decreases with increasing frequency.

b. The recovery time of the output voltage is longer for load resistance changes.

c. A large surge current causing a high power dissipation in the load occurs when the load resistance is reduced rapidly.

3-60 REVERSE VOLTAGE LOADING

3-61 A diode (CR34) is connected across the output terminals. Under normal operation conditions, the diode is reverse biased (anode connected to negative terminal). If a reverse voltage is applied to the output terminals (positive voltage applied to negative terminal), the diode will conduct, shunting current across the output terminals and limiting the voltage to the forward voltage drop of the diode. This diode protects the series transistors and the output electrolytic capacitors.

3-62 REVERSE CURRENT LOADING

3-63 Active loads connected to the power supply may actually deliver a reverse current to the power supply during a portion of its operating cycle. An external source cannot be allowed to pump current into the supply without loss of regulation and possible damage to the output capacitor. To avoid these effects, it is necessary to preload the supply with a dummy load resistor so that the power supply delivers current through the entire operation cycle of the load device.

SECTION IV
REPLACEABLE PARTS

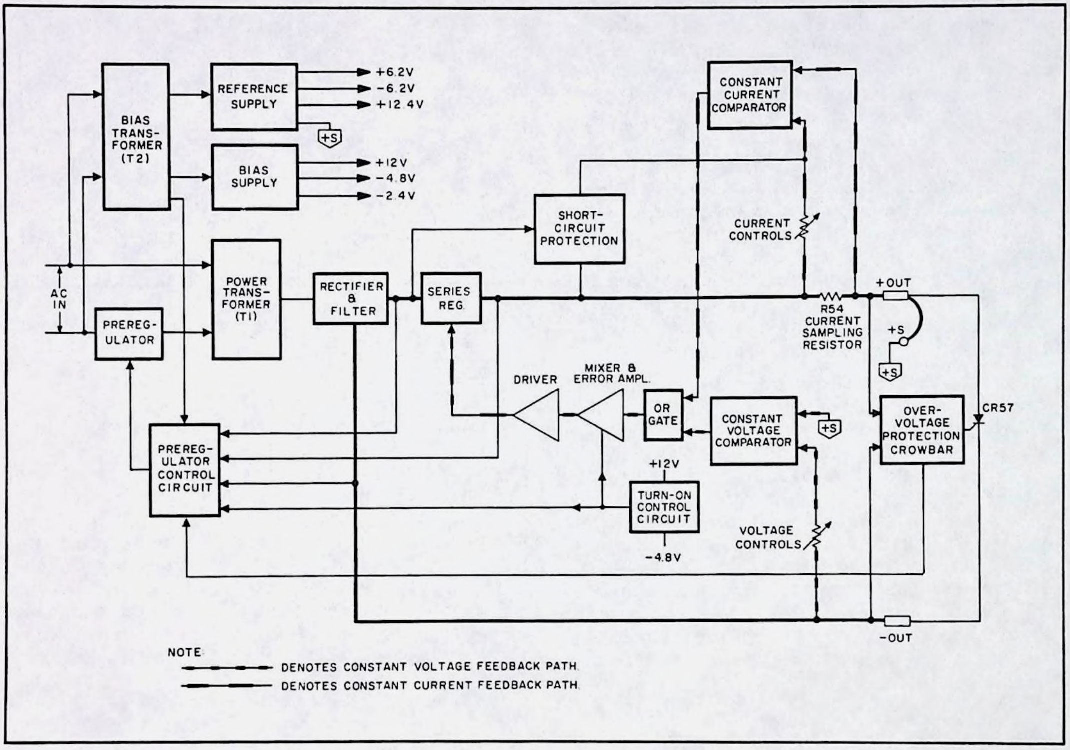


Figure 4-1. Overall Block Diagram

4-1 OVERALL BLOCK DIAGRAM DISCUSSION

4-2 The major circuits of the power supply are shown on the overall block diagram of Figure 4-1. The ac input voltage is first applied to the preregulator Triac which operates in conjunction with the preregulator control circuit to form a feedback loop. This preregulator feedback loop minimizes the power dissipated by the series regulator by keeping the voltage drop across the regulator at a low and constant level.

4-3 To accomplish this, the preregulator control circuit issues a phase adjusted firing pulse to the Triac once during each half cycle of the input ac. The control circuit continuously samples the output voltage, the input line voltage (from T2), and the voltage across the series regulator and, on the basis of these inputs, determines at what time each firing pulse is generated.

4-4 In Model 6256B, a single triac is used as the preregulator, while in Models 6264B and 6267B, two SCR's, connected in parallel, serve as the preregulator. The differences between these two devices are described in Paragraph 4-19.

4-5 The phase adjusted output of the triac is applied to the power transformer where it is stepped-down and then coupled to a full-wave rectifier and filter. The preregulated dc current is applied next to the series regulator which varies its conduction to provide a regulated voltage or current at the output terminals.

constant network which achieves a gradual turn-on characteristic. The slow turn-on feature protects the preregulator triac and the series regulator from damage which might occur when power is first applied to the unit. At turn-on, the control circuit sends inhibit voltages to the preregulator control circuit and the series regulator (via the error and driver amplifiers). A short time after the unit is in operation, the inhibit voltages are removed and the circuit no longer excercises any control over the operation of the supply.

4-15 The reference supply provides stable reference voltages which are used by the constant voltage and current comparators in the main power supply. Less critical operating voltages are obtained from the bias supply.

4-16 DETAILED CIRCUIT ANALYSIS (See Figure 7-1)

4-17 PREREGULATOR CONTROL CIRCUIT

4-18 The preregulator minimizes changes in the power dissipated by the series regulating transistors due to output voltage or input line voltage variations. Preregulation is accomplished by means of a phase control circuit utilizing triac CR25 (or SCR's CR25 and CR26) as the switching elements.

4-19 In order to understand the operation of the preregulator, it is important to understand the operation of the triac. Since the SCR's in the 6264B and 6267B are used in a conventional type of operation, the triac of the 6256B will be discussed. The triac is a bi-directional device; that is, it can conduct current in either direction. Hence, the device fires whenever it receives a gating pulse regardless of the polarity of the input ac that is applied to it. An SCR (Models 6264B and 6267B) fires when its anode is positive and it receives a positive going gating pulse. The triac is fired once during each half-cycle (8.33 milliseconds) of the input ac (see Figure 4-3). Notice that when the triac is fired at an early point during the half-cycle, the ac level applied to the power transformer is relatively high. When the triac is fired later during the cycle, the ac level is relatively low.

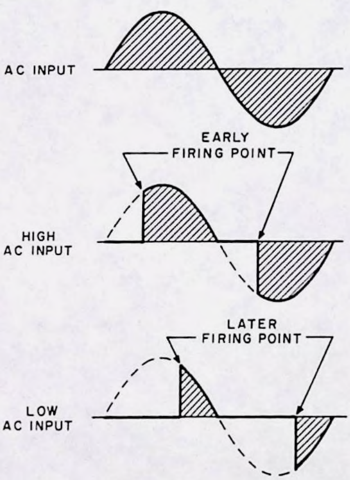


Figure 4-3. Triac Phase Control Over AC Input Amplitude

4-20 Normally the ac input signal must be at a certain minimum potential before the triac will conduct. However, C29 and R114 keep the potential across the triac slightly above this minimum so that the triac can conduct at any time during the ac input cycle.

4-21 The preregulator control circuit samples the input line voltage, the output voltage, and the voltage across the series transistor. It generates firing pulses, at the time required, to fire the triac. This action maintains the ac input voltage across the primary winding of T1 at the desired level.

4-22 The inputs to the control circuit are algebraically summed across capacitor C15. All inputs contribute to the time required to charge C15. The input line voltage is rectified by CR27, CR28, CR31, and CR33, attenuated by voltage divider R68 and R69, and applied to the summing point at TP73 via capacitor C15. Capacitor C16 is used for smoothing purposes.

4-23 Transistor Q22, connected in a common base configuration, provides a charging current for the summing capacitor which varies in accordance with the input signals applied to its emitter. Resistor R86, connected between the negative output line and the emitter of Q22, furnishes a signal which is proportional to the output voltage. Resistors R87 and R79 sample the voltage across, and the current through, the series regulator. Capacitor C17 and resistor R78 stabilize the entire preregulator feedback loop. Resistors R75 and R74 are the source of a constant offset current which sustains a net negative charging current to the summing point, ensuring that the triac will fire at low output voltages.

4-24 The summation of the input signals results in the generation of a voltage waveform at TP73 similar to that shown on Figure 4-4. When the linear ramp portion of the waveform reaches a certain negative threshold voltage, diodes CR43 and CR44 become forward biased. The negative voltage is then coupled to the base of transistor Q19. Transistors Q19 and Q18 form a squaring circuit resembling a Schmitt trigger configuration. Q19 is conducting, prior to

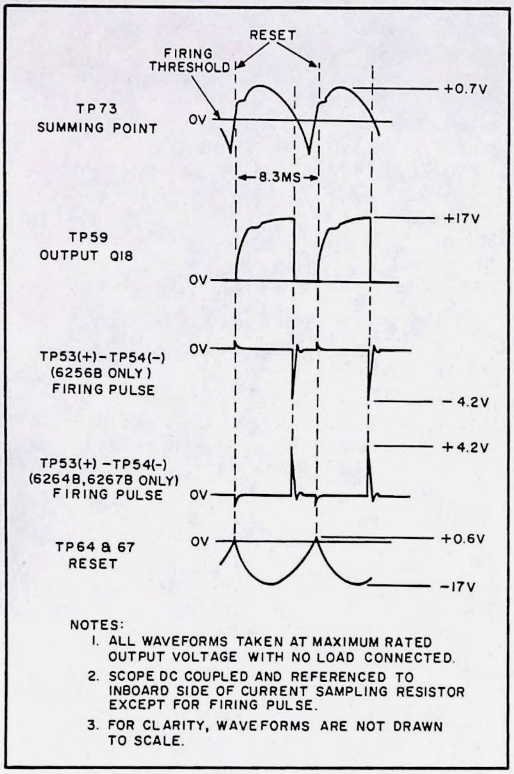


Figure 4-4. Preregulator Control Circuit Waveforms

firing time. due to the positive bias connected to its base through R73. Transistor Q18 is cut off, at this time, because its base is connected directly to the collector of transistor Q19.

4-25 When the negative threshold voltage is reached, transistor Q18 is turned off and Q18 is turned on. The conduction of Q21 allows capacitor C18 to discharge rapidly through pulse transformer T2 resulting in the generation of a firing pulse across the secondary winding of T2. As shown on Figure 4-4, each firing pulse is relatively narrow because Q18 saturates rapidly causing the magnetic field surrounding T2 to collapse. Diode CR40 damps-out positive overshoot.

4-26 Reset of the control circuit occurs once every 8.33 milliseconds when the rectified ac voltage at test point 64 increases to a level at which diode CR38 becomes forward biased. Summing capacitor C15 is then allowed to discharge through CR38. Diodes CR44 and CR43 become reverse biased at reset and transistor Q19 reverts to its "on" state. Consequently, Q18 is turned off and capacitor C18 charges up through R71 at a comparatively slow rate until the collector voltage of Q18 reaches approximately +12 Volts. The above action causes the small positive spike that appears across the windings of pulse transformer T2 at reset time.

4-27 SERIES REGULATOR AND DRIVER

4-28 The series regulator consists of transistors Q6 and Q7 connected in parallel (see schematic at rear of manual). The transistors serve as the series, or "pass", elements which provide precise and rapid control of the output. The conduction of the series transistors is controlled by the feedback signals obtained from driver Q3. Diode CR11, connected across the regulator circuit, protects the series elements from reverse voltages that could develop across them during parallel operation if one supply is turned on before the other.

4-29 SHORT CIRCUIT PROTECTION

4-30 This circuit acts to initially protect the series regulator against a full voltage-full current condition. This would occur if the output were shorted when the controls were set to high voltage output. If this condition does occur, Q13 goes into heavy conduction because of the increased voltage across the series regulator. This essentially puts R66 in parallel with the current controls reducing the voltage drop across the controls and programming the supply to some lower output current. Within 8.33 milliseconds after the short circuit is imposed, the preregulator reduces the voltage across the series regulator so that it does not exceed about 4 Volts. As the input capacitors (C13 and C14) discharge, the voltage across the series regulator will diminish to a safe level and Q13 will turn off. The output current will again rise but the voltage across the series regulator will continue to diminish to a safe 4 Volts.

4-31 CONSTANT VOLTAGE COMPARATOR

4-32 This circuit consists of the programming resistors (R11 and R10) and a differential amplifier stage (Q1 and associated components). Transistor Q1 consists of two silicon transistors housed in a single package. The transistors have matched characteristics minimizing differential voltages due to mismatched stages. Moreover, drift due to thermal differentials is minimized, since both transistors operate at essentially the same temperature.

4-33 The constant voltage comparator continuously compares the voltage drop across the VOLTAGE controls with the output voltage and, if a difference exists, produces an error voltage whose amplitude is proportional to this difference. The error signal ultimately alters the conduction of the series regulator which, in turn, alters the output current so

that the output voltage becomes equal to the voltage drop across the VOLTAGE controls. Hence, through feedback action, the difference between the two inputs to Q1 is held at zero Volts.

4-34 Stage Q1B of the differential amplifier is connected to a common (+S) potential through impedance equalizing resistor R5. Resistors R6 and R8 are used to zero bias the input stage, offsetting minor base to emitter voltage differences in Q1. The base of Q1A is connected to a summing point at (terminal A2) the junction of the programming resistors and the current pullout resistors R9, R13, and R12. Instantaneous changes in the output voltage or changes due to the manipulation of R11/R10 result in an increase or decrease in the summing point potential. Q1A is then made to conduct more or less, in accordance with summing point voltage change. The "error" voltage is taken from the collector of Q1A and ultimately varies the conduction of the series regulator.

4-35 Resistor R1, in series with the base of Q1A, limits the current through the programming resistors during rapid voltage turn-down. Diodes CR1 and CR2 form a limiting network which prevents excessive voltage excursions from over driving stage Q1A. Capacitor C1, shunting the programming resistors, increases the high frequency gain of the comparison amplifier.

4-36 During constant voltage operation, the programming current that flows through the programming resistors (VOLTAGE controls) is constant because the value of shunt resistor R13 is factory selected so that all of the +6.2 Volt reference is dropped across R9, R12, and R13. Linear constant voltage programming is assured with a constant current flowing through R11 and R10.

4-37 Main output capacitor C20, connected across the output terminals of the supply, stabilizes the series regulator feedback loop when the normal strapping pattern shown on the schematic is employed. Note that this capacitor can be removed to avoid output current surges or to increase the programming speed of the supply. If C20 is removed, capacitor C19 serves to insure loop stability.

4-38 CONSTANT CURRENT COMPARATOR

4-39 This circuit is similar in appearance and operation to the constant voltage comparator circuit. It consists of the coarse and fine current controls (R16 and R17) and a differential amplifier stage (Q2 and associated components). Like transistor Q1 in the voltage circuit, Q2 consists of two transistors, having matched characteristics, that are housed in a single package.

4-40 The constant current comparator circuit continuously compares the voltage drop across the CURRENT controls with the voltage drop across the current sampling resistor, R54. If a difference exists, the differential amplifier produces an "error" signal which is proportional to this difference. The remaining components in the feedback loop (amplifiers and series regulator) function to maintain the drop across the current sampling resistors, and hence the output current, at a constant value.

4-41 Stage Q2B is connected to the + output bus through impedance equalizing resistor R26. Instantaneous changes in the output current are felt at the current summing point (terminal A6) and, hence, the base of Q2A. The change in Q2A's conduction also varies the conduction of Q2B due to the coupling effects of the common emitter resistor, R22. The error voltage is taken from the collector Q2B and ultimately varies the conduction of the series regulator.

4-42 Resistor R19, shunting the pullout resistor, serves as a trimming adjustment for the programming current flowing through R16 and R17. Diode CR5 limits excessive voltage excursions at the base of Q2A.

4-43 VOLTAGE CLAMP CIRCUIT

4-44 The voltage clamp circuit keeps the constant voltage programming current relatively constant when the power supply is operating in the constant current mode. This is accomplished by clamping terminal A2, the voltage summing point, to a fixed bias voltage. During constant current operation the constant voltage programming resistors are a shunt load across the output terminals of the power supply. When the output voltage changes, the current through these resistors also tends to change. Since this programming current flows through the current sampling resistors, it is erroneously interpreted as a load change by the current comparator circuit. The clamp circuit eliminates this undesirable effect by maintaining this programming current constant.

4-45 The voltage divider, R51, R52, and VR3, back biases CR30 and Q10 during constant voltage operation. When the power supply goes into constant current operation, CR30 becomes forward biased by the collector voltage of Q1A. This results in conduction of Q10 and the clamping of the summing point at a potential only slightly more negative than the normal constant voltage potential. Clamping this voltage at approximately the same potential that exists in constant voltage operation, results in a constant voltage across, and consequently a constant current through, the current pullout resistors R9, R12, and R13.

4-46 MIXER AND ERROR AMPLIFIERS

4-47 The mixer and error amplifiers amplify the error signal from the constant voltage or constant current input circuit to a level sufficient to drive the series regulating transistors. Mixer amplifier Q5 receives the error voltage input from either the constant voltage or constant current comparator via the OR-gate diode (CR3 or CR4) that is conducting at the time. Diode CR3 is forward biased, and CR4 reverse biased, during constant voltage operation. The reverse is true during constant current operation.

4-48 Transistor Q11 provides a constant current to the collector of Q5 and also generates a negative going turn-off signal for the series regulator when the unit is first turned-off. Feedback network C5 and R30 shapes the high frequency rolloff in the loop gain response so as to stabilize the series regulator feedback loop.

4-49 Error amplifiers Q4 and Q12 serve as the pre-driver elements for the series regulator.

4-50 OVERVOLTAGE PROTECTION "CROWBAR"

4-51 The overvoltage protection circuit protects delicate loads from high voltage conditions. It accomplishes this by shorting the output of the supply. Under normal operation (no overvoltage), blocking oscillator Q24 and Q25, is off. (Q24 is on, Q25 is off.) Thus no trigger signal is received by SCR, CR57 and it acts as an open circuit, having no effect on normal output voltage.

4-52 R109 adjusts the bias of Q24 with relation to -S. It establishes the triggering point for the blocking oscillator. When this point is reached CR59 becomes forward biased and Q24 is turned off. With Q24 off, Q25 begins to conduct, sending a positive going trigger pulse to CR57, causing it to fire and create a near short circuit across the output. When CR57 is fired, overvoltage lamp DS1, is turned on; completing a path for a +12V unregulated holding current through DS1. This current holds CR57 on, even after the output voltage has fallen. CR57 will remain in conduction until the supply is turned off. R102 protects CR56 and CR57 from the large surge current that occurs when CR57 is first fired.

4-53 The firing of CR57 allows CR55 to become forward biased. This draws current through R71 in the preregulator control circuit which prevents the generation of any trigger pulses, and turns-off the preregulator. This prevents the series regulator from experiencing a full-voltage, full-current condition.

4-54 A slaving arrangement of the crowbar circuits in more than one unit is made possible by an extra secondary winding (terminals 5 and 6) of T4. When units having these two terminals are connected together, their crowbars will be activated if any one of the crowbars is tripped. To reset the crowbars in this arrangement, all of the units must be turned off and then on. Polarity, designated by the dots on the windings of T4 on the schematic, must be observed when connecting units in this fashion.

4-55 The crowbar circuit creates an extra current path during normal operation of the supply, thus changing the current that flows through the sampling resistor. Diode CR9 keeps this extra current at a fixed level which can then be compensated for in the constant current comparator circuit.

4-56 TURN-ON CONTROL CIRCUIT

4-57 This circuit is a long time-constant network which protects the triac and the series regulator from possible damage during turn-on. When the supply is first turned-on, C22 provides a positive voltage to the anodes of CR50 and CR47. The voltage from CR50 is connected to the cathode of diode CR44 in the preregulator control circuit to ensure that it is initially reverse biased. After C22 becomes sufficiently charged, diode CR50 becomes reverse biased and the preregulator control circuit is permitted to fire the triac.

4-58 Diode CR47 provides a similar function for the series regulator. CR47 initially couples a positive voltage to Q5 where it is inverted and applied to the series regulator. This negative voltage keeps the regulator cutoff until C22 charges up. Diode CR45 provides a discharge path for C22 when the supply is turned-off.

4-59 REFERENCE CIRCUIT

4-60 The reference circuit is a feedback power supply similar to the main supply. It provides stable reference voltages which are used throughout the unit. The total output of the reference circuit is 18.6V, with R43, VR1, and VR2 dropping the proper voltages to establish the +6.2 and +S reference voltages. The +S potential is the common point for the supply from which the +12.4, +6.2, -6.2 voltages are measured.

4-61 The regulating circuit consists of series regulating transistor Q9 and error amplifier Q8. Output voltage changes are detected by Q8 whose base is connected to the junction of a voltage divider (R41, R42) connected directly across the supply. Any changes in output voltage are amplified and inverted by Q8 and applied to the base of series transistor Q9. The series element then alters its conduction

in the direction and by the amount necessary to maintain the output voltage of the reference circuit. Resistor R46, the emitter resistor for Q8, is connected in a manner which minimizes changes in the reference voltage caused by variations in the input line. Output capacitor C9 stabilizes the regulator loop.

4-62 Diode CR20, shown in the schematic near the current pullout resistors (R9, R12, and R13), protects the zener diodes in the reference circuit by providing a path for surge currents which occur during rapid down programming.

4-63 METER CIRCUIT

4-64 The meter circuit provides continuous indications of output voltage and current on the dc voltmeter and ammeter. Both meter movements can withstand an overload of many times the maximum rated output without damage.

4-65 The ammeter together with its series resistors (R62, R63) is connected across current sampling resistor R54. As mentioned previously, the voltage drop across R54 varies in proportion to the output current. Potentiometer R63 is adjusted for full scale deflection of the ammeter.

4-66 The voltmeter is connected in series with R56 and R57 directly across the output terminals of the supply. Potentiometer R56 permits calibration of the voltmeter.

4-67 ADDITIONAL PROTECTION FEATURES

4-68 The supply contains several "special purpose" components which protect the supply in the event of unusual circumstances. One of these components is diode CR34 which is connected across the output terminals of the supply and prevents internal damage from reverse voltages that might be applied across the supply. This could occur, for example, during Auto-Series operation if one supply was turned on before the other.

4-69 Resistors R58 and R59 limit the output of the supply if the straps between both output busses and the sensing terminals (+S and -S) are inadvertently removed.

4-70 Diode CR11, previously mentioned in the series regulator description, protects the regulating transistors from the effects of reverse voltages.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance check (Paragraph 5-5) should be made. This check is suitable for incoming inspection. If a fault is detected in the power supply while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-53). After troubleshooting and repair (Paragraph 5-64), perform any necessary adjustments and calibrations (Paragraph 5-66). Before returning the power supply to normal operation, repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist.

5-3 TEST EQUIPMENT REQUIRED

5-4 Table 5-1 lists the test equipment required to perform the various procedures described in this Section.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Differential Voltmeter	Sensitivity: 1mV full scale (min.). Input impedance: 10 megohms (min.).	Measure dc voltages; calibration procedures	hp 3420 (See Note)
Variable Voltage Transformer	Range: 90-130 Volts. Equipped with voltmeter accurate within 1 Volt.	Vary ac input	-----
AC Voltmeter	Accuracy: 2%. Sensitivity: 1mV full scale deflection (min.).	Measure ac voltages and ripple.	hp 403B
Oscilloscope	Sensitivity: 100μV/cm. Differential input.	Display transient response waveforms	hp 140A plus 1400A plug-in. 1402A plug-in for spike measurements only.
Oscillator	Range: 5Hz to 600kHz. Accuracy: 2%. Output: 10V rms.	Impedance checks	hp 200CD
DC Voltmeter	Accuracy: 1%. Input resistance: 20,000 ohms/Volt (min.).	Measure dc voltages	hp 412A
Repetitive Load Switch	Rate: 60-400Hz, 2μsec rise and fall time.	Measure transient response	See Figure 5-6.
Resistive Loads	Values: See Paragraph 5-13.	Power supply load resistors	-----
Current Sampling Resistor	See R54 in Parts List (Section VI).	Measure current; calibrate meter	-----
Resistor	1KΩ ±1%, 2 Watt non-inductive.	Measure impedance	-----
Resistor	100 ohms, ±5%, 10 Watt.	Measure impedance	-----

Table 5-1. Test Equipment Required (Continued)

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Capacitor	500µf, 50WVdc.	Measure impedance	-----

NOTE

A satisfactory substitute for a differential voltmeter is to arrange a reference voltage source and null detector as shown in Figure 5-1. The reference voltage source is adjusted so that the voltage difference between the supply being measured and the reference voltage will have the required resolution for the measurement being made. The voltage difference will be a function of the null detector that is used. Examples of satisfactory null detectors are: hp 419A null detector, a dc coupled oscilloscope utilizing differential input, or a 50mV meter movement with a 100 division scale. For the latter, a 2mV change in voltage will result in a meter deflection of four divisions.

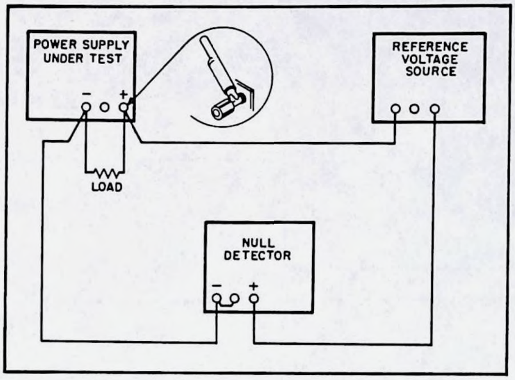


Figure 5-1. Differential Voltmeter Substitute Test Setup

CAUTION

Care must be exercised when using an electronic null detector in which one input terminal is grounded to avoid ground loops and circulating currents.

5-5 PERFORMANCE TEST

5-6 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated either to check the operation of the instrument after repairs or for periodic maintenance tests. The tests are performed using a 115Vac, 60Hz, single phase input power source. If the correct result is not obtained for a particular check, do not adjust any controls; proceed to troubleshooting (Paragraph 5-53).

5-7 CONSTANT VOLTAGE TESTS

5-8 The measuring device must be connected as close to the output terminals as possible when measuring the output impedance, transient response, regulation, or ripple of the power supply in order to achieve valid measurements. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance several orders of magnitude greater than the supply impedance, thus invalidating the measurement.

5-9 The monitoring device should be connected as shown in Figure 5-2. Note that the monitoring leads are connected at A, not B, as shown in Figure 5-2. Failure to connect the measuring device at A will result in a measurement that includes the resistance of the leads between the output terminals and the point of connection. When measuring the constant voltage performance specifications, the current controls should be set well above the maximum output current which the supply will draw, since the onset of constant current action will cause a drop in output voltage, increased ripple, and other performance changes not

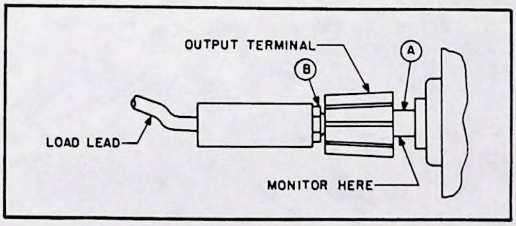


Figure 5-2. Front Panel Terminal Connections

properly ascribed to the constant voltage operation of the supply.

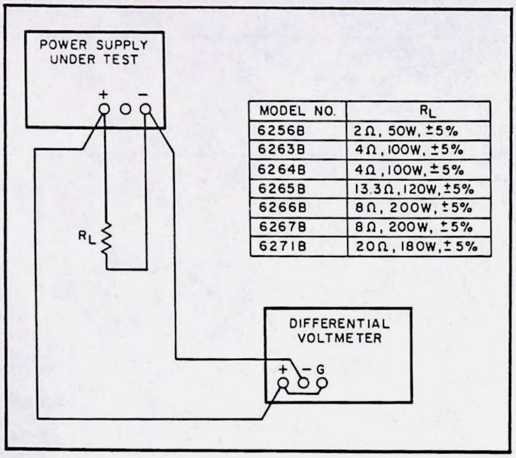


Figure 5-3. CV Load Regulation, Test Setup

5-10 Rated Output and Meter Accuracy.

5-11 Voltage. To check the output voltage, proceed as follows:

a. Connect load resistor (R_L) indicated in Figure 5-3 across the output terminals of supply.

b. Connect differential voltmeter across (+) and (-) terminals of supply observing correct polarity.

c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output voltage.

d. Differential voltmeter should indicate the following:

6263B	20 ± 0.4Vdc	6256B	10 ± 0.1Vdc
6265B, 6266B	40 ± 0.8Vdc	6264B	20 ± 0.4Vdc
6271B	60 ± 1.2Vdc	6267B	40 ± 0.8Vdc

5-12 Load Regulation.

Definition: The change ΔE_{OUT} in the static value of dc output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice versa).

5-13 To check the constant voltage load regulation, proceed as follows:

a. Connect test setup shown in Figure 5-3.

b. Turn CURRENT controls fully clockwise.

c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates maximum rated output current.

d. Read and record voltage indicated on differential voltmeter.

e. Disconnect load resistor.

f. Reading on differential voltmeter should not vary from reading recorded in step d by more than the following:

6263B	2.2mV	6256B	1.2mV
6265B, 6266B	4.2mV	6264B	2.2mV
6271B	6.2mV	6267B	4.2mV

5-14 Line Regulation

Definition: The change, ΔE_{OUT}, in the static value of dc output voltage resulting from a change in ac input voltage over the specified range from low line (usually 103 Volts) to high line (usually 127 Volts), or from high line to low line.

5-15 To check the line regulation, proceed as follows:

a. Connect variable auto transformer between input power source and power supply power input.

b. Connect test setup shown in Figure 5-3.

c. Adjust variable auto transformer for 103V ac input.

d. Turn on supply and adjust VOLTAGE controls until front panel meter indicates exactly the maximum rated output voltage.

e. Read and record voltage indicated on differential voltmeter.

f. Adjust variable auto transformer for 127V ac input.

g. Reading on differential voltmeter should not vary from reading recorded in step e by more than the following:

6263B	2.2mV	6256B	1.2mV
6265B, 6266B	4.2mV	6264B	2.2mV
6271B	6.2mV	6267B	4.2mV

5-16 Ripple and Noise.

Definition: The residual ac voltage which is superimposed on the dc output of a regulated power supply. Ripple and noise may be specified and measured in terms of its RMS or (preferably) peak-to-peak value.

Ripple and noise measurement can be made at any input AC line voltage combined with any dc output voltage and load current within rating.

5-17 The amount of ripple and noise that is present on the power supply output is measured either in terms of the RMS or (preferably) peak-to-peak value. The peak-to-peak measurement is particularly important for applications where noise spikes could be detrimental to a sensitive load, such as logic circuitry. The RMS measurement is not an ideal representation of the noise, since fairly high output noise spikes of short duration could be present in the ripple and not appreciably increase the RMS value.

5-18 Ripple and Noise Measurements. Figure 5-4A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential E_G between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting noise signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply, and can completely invalidate the measurement.

5-19 The same ground current and pickup problems can exist if an RMS voltmeter is substituted in place of the oscilloscope in Figure 5-4. However, the oscilloscope display, unlike the true RMS meter reading, tells the observer immediately whether the fundamental period of the signal displayed is 8.3 milliseconds (1/120Hz) or 16.7 milliseconds (1/60Hz). Since the fundamental ripple frequency present on the output of an hp supply is 120Hz (due to full-wave rectification), an oscilloscope display showing a 120Hz fundamental component is indicative of a "clean" measurement setup, while the presence of a 60Hz fundamental usually means that an improved setup will result in a more accurate (and lower) value of measured ripple.

5-20 Figure 5-4B shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken with a 3 to 2 adapter in series with the power supply's ac line plug. Notice, however, that the power supply case is still connected to ground via the power supply output terminals, the leads connecting these terminals to the scope terminals, the scope case and the third wire of the power supply cord.

5-21 Either a twisted pair or (preferably) a shielded two-wire cable should be used to connect the output terminals of the power supply to the vertical input terminals of the scope. When using a twisted pair, care must be taken that one of the two wires is connected both to the grounded terminal of the power supply and the grounded input terminal of the oscilloscope. When using shielded two-wire, it is essential for the shield to be connected to ground at one end only so that no ground current will flow through this shield, thus inducing a

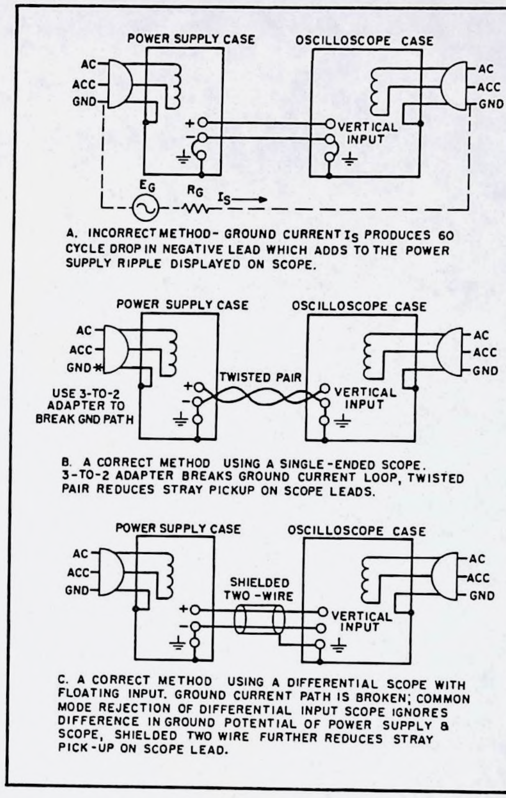


Figure 5-4. Ripple and Noise, Test Setup

noise signal in the shielded leads.

5-22 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (-) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-23 In most cases, the single-ended scope method of Figure 5-4B will be adequate to eliminate non-real components of ripple and noise so that a satisfactory measurement may be obtained. However, in more stubborn cases, or in measurement situations where it is essential that both the power supply case and the oscilloscope case be connected to ground (e.g. if both are rack-mounted), it may be necessary to use a differential scope with floating input as shown in Figure 5-4C. If desired, two single conductor shielded cables may be substituted in place of the shielded two-wire cable with equal success. Because of its

common mode rejection, a differential oscilloscope displays only the difference in signal between its two vertical input terminals, thus ignoring the effects of any common mode signal introduced because of the difference in the ac potential between the power supply case and scope case. Before using a differential input scope in this manner, however, it is imperative that the common mode rejection capability of the scope be verified by shorting together its two input leads at the power supply and observing the trace on the CRT. If this trace is a straight line, the scope is properly ignoring any common mode signal present. If this trace is not a straight line, then the scope is not rejecting the ground signal and must be realigned in accordance with the manufacturer's instructions until proper common mode rejection is attained.

5-24 To check the ripple and noise output, proceed as follows:

a. Connect the oscilloscope or RMS voltmeter as shown in Figures 5-4B or 5-4C.

b. Adjust VOLTAGE control until front panel meter indicates maximum rated output voltage.

c. The observed ripple and noise should be less than 200µVrms and 10mV p-p.

5-25 Noise Spike Measurement. When a high frequency spike measurement is being made, an instrument of sufficient bandwidth must be used; an oscilloscope with a bandwidth of 20MHz or more is adequate. Measuring noise with an instrument that has insufficient bandwidth may conceal high frequency spikes detrimental to the load.

5-26 The test setups illustrated in Figure 5-4A and 5-4B are generally not acceptable for measuring spikes; a differential oscilloscope is necessary. Furthermore, the measurement concept of Figure 5-4C must be modified if accurate spike measurement is to be achieved:

1. As shown in Figure 5-5, two coax cables must be substituted for the shielded two-wire cable.

2. Impedance matching resistors must be included to eliminate standing waves and cable ringing, and the capacitors must be connected to block the dc current path.

3. The length of the test leads outside the coax is critical and must be kept as short as possible; the blocking capacitor and the impedance matching resistor should be connected directly from the inner conductor of the cable to the power supply terminals.

4. Notice that the shields of the power supply end of the two coax cables are not connected to the power supply ground, since such a connection would give rise to a ground current path through the coax shield, resulting in an erroneous measurement.

5. Since the impedance matching resistors constitute a 2-to-1 attenuator — the noise spikes observed on the oscilloscope should be less than 5mV p-p instead of 10mV p-p.

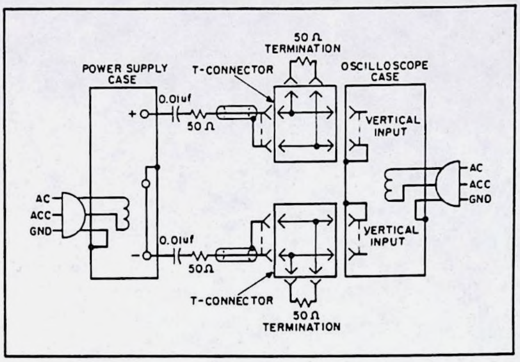


Figure 5-5. Noise Spike Measurement, Test Setup

5-27 The circuit of Figure 5-4 can also be used for the normal measurement of low frequency ripple and noise; simply remove the four terminating resistors and the blocking capacitors and substitute a higher gain vertical plug-in in place of the wide-band plug-in required for spike measurements. Notice that with these changes, Figure 5-5 becomes a two-cable version of Figure 5-4C.

5-28 <u>Output Impedance</u>

Definition: At any given frequency of load change, $\Delta E_{OUT}/\Delta I_{OUT}$. Strictly speaking the definition applies only for a sinusoidal load disturbance, unless, of course, the measurement is made at zero frequency (dc). The output impedance of an ideal constant voltage power supply would be zero at all frequencies, while the output impedance for an ideal constant current power supply would be infinite at all frequencies.

The output impedance of a power supply is normally not measured, since the measurement of transient recovery time reveals both the static and dynamic output characteristics with just one measurement. The output impedance of a power supply is commonly measured only in those cases where the exact value at a particular frequency is of engineering importance.

5-29 To check the output impedance, proceed as follows:

a. Connect test setup shown in Figure 5-6.

b. Turn on supply and adjust VOLTAGE controls until front panel meter reads 20 Volts.

c. Set AMPLITUDE control on Oscillator to 10 Volts (E_{in}) and FREQUENCY control to 100Hz.

d. Record voltage across output terminals of the power supply (E_o) as indicated on ac voltmeter.

e. Calculate the output impedance by the

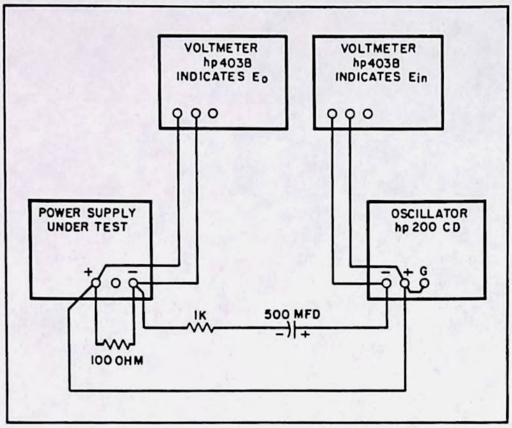


Figure 5-6. Output Impedance, Test Setup

following formula:

$$Z_{out} = \frac{E_o R}{E_{in} - E_o}$$

E_o = rms voltage across power supply output terminals.
R = 1000
E_{in} = 10 Volts

f. The output impedance (Z_{out}) should be less than 0.001 ohms.

g. Using formula of step f, calculate output impedance at frequencies of 1kHz, 100kHz and 1MHz. Values should be less than 0.01, 0.2, and 2 ohms, respectively.

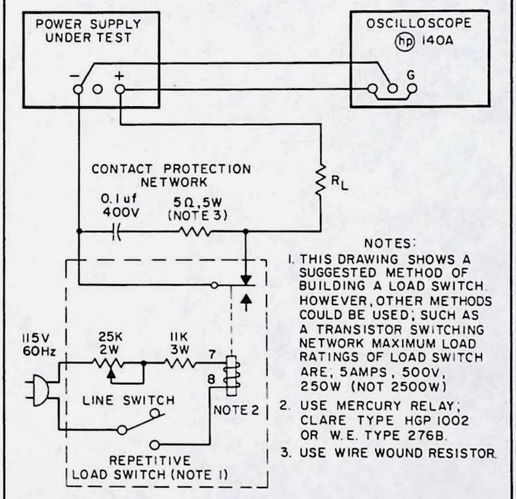
5-30 Transient Recovery Time

Definition: The time "X" for output voltage recovery to within "Y" millivolts of the nominal output voltage following a "Z" amp step change in load current — where: "Y" is specified separately for each model but is generally of the same order as the load regulation specification. The nominal output voltage is defined as the dc level half way between the static output voltage before and after the imposed load change, and "Z" is the specified load current change, normally equal to the full load current rating of the supply.

5-31 Transient recovery time may be measured at any input line voltage combined with any output voltage and load current within rating.

5-32 Reasonable care must be taken in switching the load resistance on and off. A hand-operated switch in series with the load is not adequate, since the resulting one-shot displays are difficult to observe on most oscilloscopes, and the arc energy occurring during switching action completely masks the display with a noise burst. Transistor load switching devices are expensive if reasonably rapid load current changes are to be achieved.

5-33 A mercury-wetted relay, as connected in the load switching circuit of Figure 5-7 should be used for loading and unloading the supply. When this load switch in connected to a 60Hz ac input, the mercury-wetted relay will open and close 60 times per second. Adjustment of the 25K control permits adjustment of the duty cycle of the load current switching and reduction in jitter of the oscilloscope display.



MODEL NO.	R_L
6256B	2 Ω, 50W, ± 5%
6263B	4 Ω, 100W, ± 5%
6264B	4 Ω, 100W, ± 5%
6265B	13.3 Ω, 120W, ± 5%
6266B	8 Ω, 200W, ± 5%
6267B	8 Ω, 200W, ± 5%
6271B	20 Ω, 180W, ± 5%

Figure 5-7. Transient Recovery Time, Test Setup

5-34 The maximum load ratings listed in Figure 5-7 must be observed in order to preserve the mercury-wetted relay contacts. Switching of larger load currents can be accomplished with mercury pool relays; with this technique fast rise times can still be obtained, but the large inertia of mercury pool

relays limits the maximum repetition rate of load switching and makes the clear display of the transient recovery characteristic on an oscilloscope more difficult.

5-35 To check the transient recovery time, proceed as follows:

a. Connect test setup shown in Figure 5-7.

b. Turn on supply and adjust voltage controls until front panel meter indicates exactly the maximum rated output current.

c. Close the line switch on the repetitive load switch setup.

d. Set the oscilloscope for internal sync and lock on either the positive or negative load transient spike.

e. Set the vertical input of the oscilloscope for ac coupling so that small dc level changes in the output voltage of the power supply will not cause the display to shift.

f. Adjust the vertical centering on the scope so that the tail ends of the no load and full load waveforms are symmetrically displaced about the horizontal center line of the oscilloscope. This center line now represents the nominal output voltage defined in the specification.

g. Adjust the horizontal positioning control so that the trace starts at a point coincident with a major graticule division. This point is then representative of time zero.

h. Increase the sweep rate so that a single transient spike can be examined in detail.

i. Adjust the sync controls separately for the positive and negative going transients so that not only the recovery waveshape but also as much as possible of the rise time of the transient is displayed.

j. Starting from the major graticule division representative of time zero, count to the right 50μ sec and vertically 10mV. Recovery should be within these tolerances as illustrated in Figure 5-8.

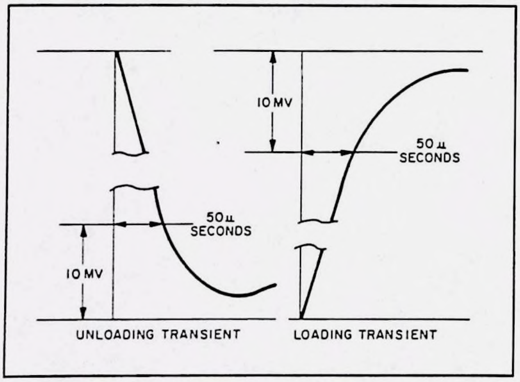


Figure 5-8. Transient Recovery Time, Waveforms

5-36 <u>Temperature Coefficient</u>

Definition: The change in output voltage per degree centigrade change in the ambient temperature under conditions of constant input ac line voltage, output voltage setting, and load resistance.

5-37 The temperature coefficient of a power supply is measured by placing the power supply in an oven and varying it over any temperature span within its rating. (Most hp power supplies are rated for operation from 0°C to 55°C.) The power supply must be allowed to thermally stabilize for a sufficient period of time at each temperature of measurement.

5-38 The temperature coefficient specified is the maximum temperature-dependent output voltage change which will result over any 5°C interval. The differential voltmeter or digital voltmeter used to measure the output voltage change of the supply should be placed outside the oven and should have a long term stability adequate to insure that its drift will not affect the overall measurement accuracy.

5-39 To check the temperature coefficient, proceed as follows:

a. Connect the load resistance, and differential voltmeter as illustrated in Figure 5-3.

b. Adjust front panel VOLTAGE controls until the front panel voltmeter indicates maximum rated output voltage.

c. Insert the power supply into the temperature-controlled oven (differential voltmeter remains outside oven). Set the temperature to 30°C and allow 30 minutes warm-up.

d. Record the differential voltmeter indication.

e. Raise the temperature to 40°C and allow 30 minutes warm-up.

f. Observe the differential voltmeter indication. The difference in the voltage indication of step d and f should be less than the following:

6256B	12mV	6265B, 6266B, 6267B	42mV
6263B, 6264B	22mV	6271B	62mV

5-40 <u>Output Stability.</u>

Definition: The change in output voltage for the first eight hours following a 30 minute warm-up period. During the interval of measurement all parameters, such as load resistance, ambient temperature, and input line voltage are held constant.

5-41 This measurement is made by monitoring the output of the power supply on a differential voltmeter or digital voltmeter over the stated measurement interval; a strip chart recorder can be used to provide a permanent record. A thermometer should be placed near the supply to verify that the ambient

temperature remains constant during the period of measurement. The supply should be put in a location immune from stray air currents (open doors or windows, air conditioning vents); if possible, the supply should be placed in an oven which is held at a constant temperature. Care must be taken that the measuring instrument has a stability over the eight hour interval which is at least an order of magnitude better than the stability specification of the power supply being measured. Typically, a supply may drift less over the eight hour measurement interval than during the $\frac{1}{2}$ hour warm-up period.

5-42 To check the output stability, proceed as follows:

a. Connect the load resistance and differential voltmeter as illustrated in Figure 5-3.

b. Adjust front panel VOLTAGE controls until the differential voltmeter indicates maximum rated output voltage.

c. Allow 30 minutes warm-up then record the differential voltmeter indication.

d. After 8 hours, differential voltmeter should change from indication recorded in step c by less than the following:

6256B	3.5mV	6265B, 6266B, 6267B	12.5mV
6263B, 6264B	6.5mV	6271B	18.5mV

5-43 CONSTANT CURRENT TESTS

5-44 For output current measurements, the current sampling resistor must be treated as a four terminal device. In the manner of a meter shunt, the load current is fed to the extremes of the wire leading to the resistor while the sampling terminals are located as close as possible to the resistance portion itself (see Figure 5-9). Generally, any current sampling resistor should be of the low noise, low temperature coefficient (less than 30ppm/°C) type and should be used at no more than 5% of its rated power so that its temperature rise will be minimized. The latter, reduces resistance changes due to thermal fluctuations. It is recommended that the user obtain a duplicate of the sampling resistance (R54) that is used in this unit for constant current checks.

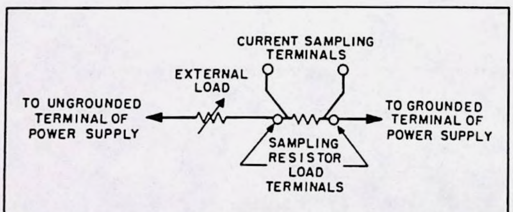


Figure 5-9. Current Sampling Resistor Connections

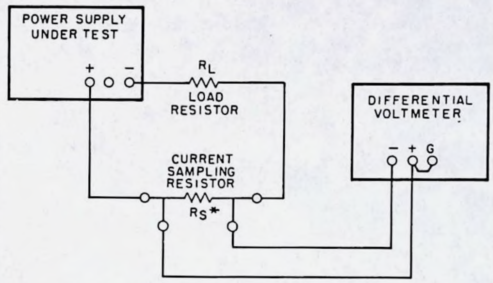
5-45 Rated Output and Meter Accuracy

a. Connect test setup shown in Figure 5-10.

b. Turn CURRENT controls fully clockwise.

c. Turn on supply and adjust VOLTAGE controls until front panel meter indicates maximum rated output current.

d. Differential voltmeter should read 0.5 ± .01Vdc.



* REFER TO R54 IN PARTS LIST (SECTION VI)

MODEL NO.	R_L
6256B	2Ω, 50W, ±5%
6263B	4Ω, 100W, ±5%
6264B	4Ω, 100W, ±5%
6265B	13.3Ω, 120W, ±5%
6266B	8Ω, 200W, ±5%
6267B	8Ω, 200W, ±5%
6271B	20Ω, 180W, ±5%

Figure 5-10. Constant Current, Test Setup

5-46 Load Regulation

Definition: The change, ΔI_{OUT} in the static value of the dc output current resulting from a change in load resistance from short circuit to a value which yields maximum rated output voltage.

5-47 To check the constant current load regulation, proceed as follows:

a. Connect test setup shown in Figure 5-10.

b. Turn VOLTAGE control(s) fully clockwise.

c. Adjust CURRENT control until front panel meter reads exactly the maximum rated output current.

d. Read and record voltage indicated on differential voltmeter.

e. Short out load resistor (R_L).

f. Reading on differential voltmeter should not vary from reading recorded in step d by more than the following:

6256B	112μV	6265B, 6271B	183μV
6263B, 6267B	125μV	6266B	250μV
6264B	113μV		

5-48 <u>Line Regulation</u>
Definition: The change, ΔI_{OUT} in the static value of dc output current resulting from a change in ac input voltage over the specified range from low line (usually 103 Volts) to high line (usually 127 Volts), or from high line to low line.

5-49 To check the line regulation proceed as follows:

a. Utilize test setup shown in Figure 5-10.

b. Connect variable auto transformer between input power source and power supply power input.

c. Adjust auto transformer for 103Vac input.

d. Turn VOLTAGE control(s) fully clockwise.

e. Adjust CURRENT controls until front panel meter reads exactly the maximum rated output current.

f. Read and record voltage indicated on differential voltmeter.

g. Adjust variable auto transformer for 127 Vac input.

h. Reading on differential voltmeter should not vary from reading recorded in step f by more than the following:

6256B	112µV	6265B, 6271B	183µV
6263B, 6267B	125µV	6266B	250µV
6264B	113µV		

5-50 <u>Ripple and Noise</u>
Definition: The residual ac current which is superimposed on the dc output current of a regulated supply. Ripple and noise may be specified and measured in terms of its RMS or (preferably) peak-to-peak value.

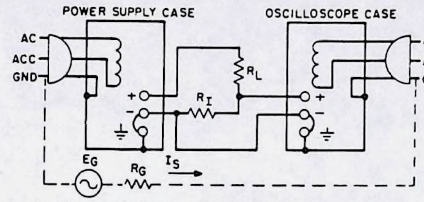
5-51 Most of the instructions pertaining to the ground loop and pickup problems associated with constant voltage ripple and noise measurement also apply to the measurement of constant current ripple and noise. Figure 5-11 illustrates the most important precautions to be observed when measuring the ripple and noise of a constant current supply. The presence of a 120 cycle waveform on the oscilloscope is normally indicative of a correct measurement method. A waveshape having 60Hz as its fundamental component is typically associated with an incorrect measurement setup.

5-52 Ripple and Noise Measurement. To check the ripple and noise, proceed as follows:

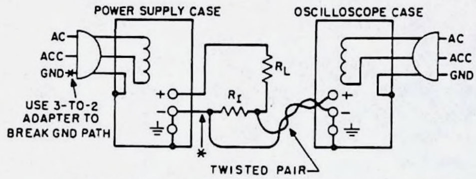
a. Connect the RMS voltmeter as shown in Figures 5-11B or 5-11C.

b. Rotate the VOLTAGE control fully cw and turn on supply.

c. Adjust CURRENT control until front panel meter reads exactly the maximum rated output current.

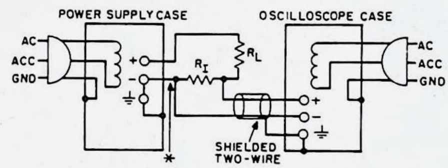


A. INCORRECT METHOD – GROUND CURRENT I_S PRODUCES 60 CYCLE DROP IN NEGATIVE LEAD WHICH ADDS TO THE POWER SUPPLY RIPPLE DISPLAYED ON SCOPE.



* LENGTH OF LEAD BETWEEN R_I AND GROUNDED OUTPUT TERMINAL OF POWER SUPPLY MUST BE HELD TO ABSOLUTE MINIMUM.

B. A CORRECT METHOD USING A SINGLE-ENDED SCOPE. 3-TO-2 ADAPTER BREAKS GROUND CURRENT LOOP, TWISTED PAIR REDUCES STRAY PICKUP ON SCOPE LEADS.



* LENGTH OF LEAD BETWEEN R_I AND GROUNDED OUTPUT TERMINAL OF POWER SUPPLY MUST BE HELD TO ABSOLUTE MINIMUM.

C. A CORRECT METHOD USING A DIFFERENTIAL SCOPE WITH FLOATING INPUT. GROUND CURRENT PATH IS BROKEN; COMMON MODE REJECTION OF DIFFERENTIAL INPUT SCOPE IGNORES DIFFERENCE IN GROUND POTENTIAL OF POWER SUPPLY & SCOPE, SHIELDED TWO-WIRE FURTHER REDUCES STRAY PICKUP ON SCOPE LEAD.

NOTES:
FOR RATING OF R_I, REFER TO R54 IN PARTS LIST, SECTION VI.

MODEL NO.	R_L
6256B	2Ω, 50W, ±5%
6263B	4Ω, 100W, ±5%
6264B	4Ω, 100W, ±5%
6265B	13.3Ω, 120W, ±5%
6266B	8Ω, 200W, ±5%
6267B	8Ω, 200W, ±5%
6271B	20Ω, 180W, ±5%

Figure 5-11. Constant Current Ripple and Noise, Test Setup

d. The ripple and noise indication should be less than:

6256B, 6264B	125µVrms	6265B, 6271B	494µVrms
6263B, 6267B	150µVrms	6266B	300µVrms

5-53 TROUBLESHOOTING

5-54 Before attempting to troubleshoot this instrument, ensure that the fault is with the instrument and not with an associated circuit. The performance test (Paragraph 5-5) enables this to be determined without having to remove the instrument from the cabinet.

5-55 A good understanding of the principles of operation is a helpful aid in troubleshooting, and it is recommended that the reader review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, refer to the overall troubleshooting procedures in paragraph 5-58 to locate the symptom and probable cause.

5-56 The schematic diagram at the rear of the manual contains normal voltage readings taken at various points within the circuits. These voltages are positioned adjacent to the applicable test points (identified by encircled numbers). For Models 6256B, 6264B and 6267B supplies, the component location diagram at the rear of the manual should be consulted to determine the location of components and test points.

5-57 If a defective component is located, replace it and re-conduct the performance test. When a component is replaced, refer to the repair and replacements and adjustment and calibration paragraphs in this section.

5-58 OVERALL TROUBLESHOOTING PROCEDURE

5-59 To locate the cause of trouble, follow steps 1, 2, and 3 in sequence:

(1) Check for obvious troubles such as open fuse, defective power cord, input power failure or defective meter. Next remove top cover and inspect for open connections, charred components, etc. If trouble source cannot be detected by visual inspection, proceed to step 2.

(2) In almost all cases, the trouble can be caused by dc bias or reference voltages; thus, it is a good practice to check voltages in Table 5-2, before proceeding with step 3.

(3) Disconnect load and examine Table 5-3 to determine your symptom and probable cause.

Table 5-2. Reference and Bias Voltages
(Refer to Schematic for test point locations)

STEP	METER COMMON	METER POSITIVE	NORMAL VDC	NORMAL RIPPLE (P-P)	PROBABLE CAUSE
1	+S	31	12.4 ±5%	10mV	Q9, Q8
2	+S	25	6.2 ±5%	1mV	VR1, VR2, Q9, Q8
3	24	+S	6.2 ±5%	1.5mV	VR1, VR2, Q9, Q8
4	+S	44	12 ±10%	2V	C12
5	45	+S	4.8 ±10%	.3V	C12
6	80	+S	2.4 ±10%	.3V	VR6, VR7

Table 5-3. Overall Troubleshooting

SYMPTOM	PROBABLE CAUSE
Low or No Output Voltage (Overvoltage lamp may be on or off)	a. Front panel meter defective. b. Series regulator or preregulator feedback loop defective. Refer to Table 5-4. c. "Crowbar" not reset or defective. Refer to Table 5-4.

Table 5-3. Overall Troubleshooting (Continued)

SYMPTOM	PROBABLE CAUSE
High Output Voltage	a. Front panel meter defective b. Series regulator or preregulator loop defective. If "Crowbar" does not trip, it too is faulty. Refer to Table 5-4.
Poor Line Regulation	a. Improper measurement technique. Refer to Paragraph 5-14. b. Incorrect reference and/or bias voltages. Refer to Table 5-2.
Poor Load Regulation (Constant Voltage)	a. Improper measurement technique. Refer to Paragraph 5-12. b. Incorrect reference and/or bias voltages. Refer to Table 5-2. c. Supply current limiting. Check constant current comparator circuit (Q2 and associated components).
Poor Load Regulation (Constant Current)	a. Incorrect reference and/or bias voltages. Refer to Table 5-2. b. Supply voltage limiting. Check constant voltage comparator circuit (Q1 and associated components) and voltage clamp circuit, Q10. c. C19, CR20, leaky.
Oscillates (Constant Current/Constant Voltage)	a. Adjustment of R30. Refer to Paragraph 5-64. b. Faulty C5, C6, C19, R33. c. Open sensing lead (+S).
Instability (Constant Current/Constant Voltage)	a. Incorrect reference and/or bias voltages, CR9 defective. Refer to Table 5-2. b. Noisy voltage or current controls (R10, R11 or R16, R17). c. Stage Q1 or Q2 defective. d. CR1, CR2 or CR5 leaky. e. R1, R12, R13, R18, R19, R20, C1 noisy or drifting.
Cannot Reach Maximum Output	a. Q13 shorted.

5-60 Table 5-3 contains symptoms and probable causes of many possible troubles. If either high or low output voltage is a symptom, Table 5-4 contains the steps necessary to isolate the trouble to one of the feedback loops and instructions directing the tester to the proper table for further isolation. Because of the interaction between loops, it is necessary to refer to Table 5-4 before proceeding to Tables 5-5, 5-6 or 5-7.

5-61 Tables 5-5, 5-6 and 5-7 contain troubleshooting the series regulator and preregulator feedback loops once the fault has been isolated to either one. Tables 5-5 and 5-6 contain instructions for driving each stage into conduction or cutoff by shorting or opening a transistor. By following the steps in these tables, the fault can be isolated to a circuit or a component.

Table 5-4. Feedback Loop Isolation

STEP	ACTION	RESPONSE	PROBABLE CAUSE
	NOTE: After each step, crowbar should be reset by turning supply off and then on.		
1	Inspect fuses.	a. Blown	a. Check rectifier and filter for short. Faulty preregulator. Proceed to Table 5-7.
		b. Not blown; High voltage output	b. Check CR57 for open, Q25 for open, Q24 for short. Check setting of overvoltage adjust (R109). Also check series regulator loop for high voltage condition, Table 5-5.
		c. Not blown; Low voltage output	c. Proceed to Step 2.
2	Inspect overvoltage lamp on front panel.	a. On	a. Check CR57 for short, Q25 for short, Q24 for open. Check setting of overvoltage adjust (R109). Then check series regulator loop for high voltage condition, Table 5-5.
		b. Off; High voltage output	b. Check CR57 for open, Q25 for open, Q24 for short. Check overvoltage adjust (R109). Also check series regulator loop for high voltage condition, Table 5-5.
		c. Off; Low voltage output	c. Check CR57 for short, Q25 for open, Q24 for short. Check overvoltage adjust (R109). Check Q13 for short. Proceed to Step 3.
3	Isolate fault to either series regulator or preregulator by using the following steps: 1. Open the gate lead to triac CR25 (6256B) or SCRs CR25 and CR26 (6264B and 6267B). 2. Place a small dc power supply across the input capacitors (C13 and C14). A 0-10V, 1 Ampere supply is sufficient. 3. Set external supply to ten Volts. 4. Vary front panel voltage controls.	a. Output voltage normal. Variable from 0 Volts to about 6 Volts.	a. Faulty preregulator. Disconnect source and proceed to Table 5-7.
		b. Output voltage high. Varying controls has little or no effect.	b. High voltage condition in series regulator. Proceed to Table 5-5.
		c. Output voltage low. Varying controls has little or no effect.	c. Low voltage condition in series regulator loop. Proceed to Table 5-6. Leave external source connected.

Table 5-5. Series Regulator Troubleshooting, High Voltage Condition

STEP	ACTION	RESPONSE	PROBABLE CAUSE
These tests should be made with external source connected as described in Table 5-4, Step 3.			
1	Check turn-off of series regulator transistors by shorting terminal A4 to base of Q3	a. Output voltage remains high b. Output voltage decreases	a. Q6, Q7, CR11 or Q3 shorted. b. Remove short. Proceed to Step 2.
2	Check conduction of Q4 by shorting Q12 emitter to collector	a. Output voltage remains high b. Output voltage decreases	a. Q4 open. b. Remove short. Proceed to Step 3.
3	Check conduction of Q12 by shorting Q11 emitter to collector	a. Output voltage remains high b. Output voltage decreases	a. Q12 open. b. Remove short. Proceed to Step 4.
4	Check turn-off of Q5 by shorting Q1B emitter to base	a. Output voltage decreases b. Output voltage remains high	a. Q1A shorted. Q1B opened. Opened strap between A1 and A2. R10 or R11 open. b. Q5 shorted.
NOTE: If trouble still exists, check preregulator, Table 5-7.			

Table 5-6. Series Regulator Troubleshooting, Low Voltage Condition

STEP	ACTION	RESPONSE	PROBABLE CAUSE
These tests should be made with external source connected as described in Table 5-4, Step 3.			
1	Check turn-on of Q6 and Q7 by shorting Q3 emitter to collector	a. Output voltage remains low b. Output voltage rises	a. Q6, Q7 open. b. Check Q3 for open. Remove short. Proceed to Step 2.
2	Check turn-off of Q4 by opening the emitter of Q12	a. Output voltage remains low b. Output voltage rises	a. Q4 shorted. b. Reconnect lead and proceed to Step 3.
3	Check turn-off of Q12 by shorting Q5 emitter to collector	a. Output voltage remains low b. Output voltage rises	a. Q12 shorted. b. Reconnect lead and proceed to Step 4.

Table 5-6. Series Regulator Troubleshooting, Low Voltage Condition (Continued)

STEP	ACTION	RESPONSE	PROBABLE CAUSE
4	Isolate fault to either constant voltage comparator or constant current comparator by opening the cathode of CR4	a. Output voltage rises	a. Check Q2A for short, Q2A for open; open strap between A6 and A7 or shorted R16 or R17.
		b. Output voltage remains low	b. Reconnect lead and proceed to Step 5.
5	Check turn-on of Q5 by shorting Q1A emitter to collector	a. Output voltage remains low	a. Q5 open.
		b. Output voltage rises	b. Disconnect short. Check Q1A for open, Q1B for short. Check for open strap between A2 and A3. Check R9 and R10 for short.
NOTE: If trouble still exists, check preregulator, Table 5-7.			

Table 5-7. Preregulator Troubleshooting

STEP	ACTION	RESPONSE	PROBABLE CAUSE
CAUTION: Test equipment must be used floating for these tests. NOTE: For these tests, refer to waveforms next to schematic.			
1	Connect oscilloscope between TP59 and TP81	a. Normal waveform	a. Defective CR25 (6264B, 6267B; CR25 and CR26), CR40 (CR39 and CR40), R84 (R83 and R84), T1, CR21 or CR24.
		b. Little or no voltage	b. Defective Q18, Q19 or C18. Proceed to Step 2.
2	Connect oscilloscope between TP73 and TP81	a. Amplitude incorrect	a. Defective Q22, C15, CR43, CR44, R78, R87 or R86.
		b. Period incorrect	b. CR38 defective. Proceed to Step 4.
3	Connect oscilloscope between TP64 and TP81	a. Amplitude, dc reference or period incorrect	a. Defective CR27, CR28, CR33 or CR36. Proceed to Step 4.
4	Connect oscilloscope between TP67 and TP81	a. Amplitude or period incorrect	a. Defective CR27, CR31, CR33. Check R68, R69, C15 and C16.

5-62 Table 5-7 contains troubleshooting of the preregulator feedback loops. This is accomplished by comparing listed waveforms with those found at various test points and then listing most obvious components which might be at fault.

5-63 After troubleshooting unit, it may be necessary to perform one or more of the calibrations listed in this section.

5-64 REPAIR AND REPLACEMENT

5-65 Before servicing a printed wiring board, refer to Figure 5-12. Section VI of this manual contains a list of replaceable parts. Before replacing a semiconductor device, refer to Table 5-8 which lists the special characteristics of selected semiconductors. If the device to be replaced is not listed in Table 5-8, the standard manufacturers' part number listed in Section VI is applicable. After replacing a semiconductor device, refer to Table 5-9 for checks and adjustments that may be necessary.

Table 5-8. Selected Semiconductor Characteristics

REFERENCE DESIGNATOR	CHARACTERISTICS	hp PART NO.	SUGGESTED REPLACEMENT
Q6, 7	h_{FE} = 25 min. @ I_c = 15A; V_{CE} = 4V. V_{CE} (sat.) = 1V max. @ I_c = 15A; I_b = 1.5A. V_{be} = 1V max. @ I_c = 15A; V_{CE} = 4V. V_{ceo} (sus.) = 25V min. @ I_c = 0.2A; I_b = 0.	1854-0245	2N3771 R.C.A.

Table 5-9. Checks and Adjustments After Replacement of Semiconductor Devices

REFERENCE	FUNCTION	CHECK	ADJUST
Q1	Constant voltage differential amplifier	Constant voltage (CV) line and load regulation. Zero Volt output.	R6 or R8
Q2	Constant current differential amplifier	Constant current (CC) line and load regulation. Zero current output.	R25 or R28
Q5, Q11	Mixer amplifier	CV/CC load regulation. CV transient response.	R30
Q4, Q12	Error amplifiers and driver	CV/CC load regulation.	
Q6, Q7	Series regulator	CV/CC load regulation.	
Q8, Q9	Reference regulator	Reference circuit line regulation.	R46
Q10	Clamp circuit	CC load regulation.	
Q18, 19, 22	SCR control	Output voltage.	R75
Q24, Q25	Crowbar	Trip voltage.	R109
CR1, CR2	Limiting diodes	CV load regulation.	
CR3, CR4, CR5	OR-gate diodes and limiting diode	CV/CC load regulation.	

Table 5-9. Checks and Adjustments After Replacement of Semiconductor Devices (Continued)

REFERENCE	FUNCTION	CHECK	ADJUST
CR10, 12-14, CR21-24, 31, CR33, 27, 28	Rectifier diodes	Voltage across appropriate filter capacitor.	
CR34	Protection diode	Output voltage.	
CR25 (and CR26)	Preregulator	Output voltage.	R75
VR1	Positive reference voltage	Positive reference voltage (+6. 2V).	
VR2	Negative reference voltage	Negative reference voltage (-6. 2V).	
VR6	Bias voltage	-4. 8	
VR7	Bias voltage	-2. 4	

5-66 ADJUSTMENT AND CALIBRATION

5-67 Adjustment and calibration may be required after performance testing, troubleshooting. or repair and replacement. Perform only those adjustments that affect the operation of the faulty circuit and no others.

5-68 METER ZERO

5-69 The meter pointer must rest on the zero calibration mark on the meter scale when the instrument is at normal operating temperature, resting in its normal operating position, and the instrument is turned off. To zero-set the meter proceed as follows:

a. Turn on instrument and allow it to come up to normal operating temperature (about 20 minutes).

b. Turn the instrument off. Wait one minute for power supply capacitors to discharge completely.

c. Insert sharp pointed object (pen point or awl) into the small identation near top of round black plastic disc located directly below meter face.

d. Rotate plastic disc clockwise (cw) until meter reads zero, then rotate ccw slightly in order to free adjustment screw from meter suspension. If pointer moves, repeat steps c and d.

5-70 VOLTMETER TRACKING

5-71 To calibrate the voltmeter, proceed as follows:

a. Connect differential voltmeter across supply, observing correct polarity.

b. Turn on supply and adjust VOLTAGE controls until differential voltmeter reads exactly the maximum rated output voltage.

c. Adjust R56 until front panel voltmeter also indicates maximum rated output voltage.

5-72 AMMETER TRACKING

5-73 To calibrate ammeter tracking, proceed as follows:

a. Connect test setup shown on Figure 5-10.

b. Turn VOLTAGE controls fully clockwise.

c. Turn on supply and adjust CURRENT controls until differential voltmeter reads 0.5Vdc.

d. Adjust R63 until front panel ammeter indicates maximum rated output current.

5-74 CONSTANT VOLTAGE PROGRAMMING CURRENT

5-75 Zero Output Voltage. To calibrate the zero Volt programming accuracy, proceed as follows:

a. Connect differential voltmeter between +S and -S terminals.

b. Short-out voltage controls by connecting jumper between terminals A1 and -S.

c. Rotate CURRENT controls fully clockwise and turn on supply.

d. Observe reading on differential voltmeter.

e. If it is more positive than 0 Volts, shunt resistor R6 with decade resistance box.

f. Adjust decade resistance until differential voltmeter reads zero, then shunt R6 with re-

sistance value equal to that of the decade resistance.

g. If reading of step d is more negative than 0 Volts, shunt resistor R8 with the decade resistance box.

h. Adjust decade resistance until differential voltmeter reads zero then shunt R8 with resistance value equal to that of the decade box.

5-76 CV Programming Accuracy. To calibrate the constant voltage programming current, proceed as follows:

a. Connect a 0.1%, 1/8 Watt resistor between terminals -S and A3 on rear barrier strip.

Model	Value	Model	Value
6256B	2K	6265B, 6266B, 6267B	8K
6263B, 6264B	4K	6271B	18K

b. Disconnect jumper between A1 and A2 on rear terminal barrier strip.

c. Connect a decade resistance in place of R13.

d. Connect a differential voltmeter between +S and -S and turn on supply.

e. Adjust decade resistance box so that differential voltmeter indicates maximum rated output voltage.

f. Replace decade resistance with resistor of appropriate value in R13 position.

5-77 CONSTANT CURRENT PROGRAMMING CURRENT

5-78 Zero Output Current. To calibrate the zero current programming accuracy, proceed as follows:

a. Connect test setup shown on Figure 5-10.

b. Short out current controls by connecting jumper between terminals A4 and A5.

c. Rotate VOLTAGE controls fully clockwise and turn on supply.

d. Observe reading on differential voltmeter.

e. If it is more positive than 0 Volts, shunt resistor R25 with a decade resistance box.

f. Adjust decade resistance until differential voltmeter reads zero, then shunt R25 with resistance value equal to that of decade resistance.

g. If reading of step d is more negative than 0 Volts, shunt resistor R28 with decade resistance.

h. Adjust decade resistance until differential voltmeter reads zero, then shunt R28 with resistance value equal to that of decade box.

5-79 CC Programming Accuracy. To calibrate the constant current programming current, proceed as follows:

a. Connect power supply as shown in Figure 5-10.

b. Remove strap between A5 and A6.

c. Connect a 0.1%, 1/8 Watt resistor between A4 and A6.

Model	Value	Model	Value
6256B, 6264B	200Ω	6265B, 6271B	900Ω
6263B, 6266B	1KΩ	6267B	1000Ω

d. Connect decade resistance box in place of R19.

e. Adjust the decade resistance so that the differential voltmeter indicates 0.5Vdc.

f. Replace decade resistance with appropriate value resistor in R19 position.

5-80 TRANSIENT RECOVERY TIME

5-81 To adjust the transient response, proceed as follows:

a. Connect test setup as shown in Figure 5-8.

b. Repeat steps a through h as outlined in Paragraph 5-35.

c. Adjust R30 so that the transient response is as shown in Figure 5-8.

5-82 RIPPLE IMBALANCE

5-83 This procedure ensures that the power dissipated by the two preregulator SCR's is approximately equal (within 25%). To check for imbalance proceed as follows:

a. Connect proper load resistance across output terminals of supply.

b. Connect oscilloscope (ac coupled) between TP47 and TP81 (across series regulator).

c. Turn on supply and adjust VOLTAGE controls for maximum rated output.

d. Adjust oscilloscope to observe 120Hz sawtooth waveform. Peak amplitudes of adjacent sawtooth peaks should be within 25% of each other.

e. If amplitude difference is greater than 25%, turn off supply and replace R78 with decade resistance.

f. Turn on supply and adjust decade resistance to reduce imbalance to within 25%.

g. Vary input line voltage and insure that imbalance does not exist anywhere within the line rating.

5-84 PREREGULATOR TRACKING

5-85 To adjust the voltage drop across the series regulator, proceed as follows:

a. Connect test setup shown on Figure 5-3 except connect dc voltmeter across series regulator (TP47 and TP81) and attach a variac to the input ac line.

b. To check drop at low output voltage, turn on supply, short out load resistor, and adjust VOLTAGE controls for maximum rated output current on front panel meter.

c. Adjust R75 until voltmeter indicates 3.7V.

d. To check voltage drop at high output voltage, remove short across R_L, and adjust VOLTAGE controls for maximum rated output current.

e. Vary input line voltage between 103 and 126Vac. Voltmeter reading should be between 3.1 and 4.3V. If not, proceed with step f.

f. Replace R76 with decade box. Vary line voltage between 103 and 126Vac and adjust decade box until voltmeter reading is between 3.1 and 4.3V. Replace decade box with an equivalent resistor.

5-86 CROWBAR TRIP VOLTAGE

5-87 To adjust R109, proceed as follows:

a. Turn screwdriver adjustment, R109, fully clockwise.

b. Turn on supply.

c. Set voltage output to desired trip voltage.

d. Turn R109 slowly counterclockwise until the crowbar is tripped (meter falls to zero volts).

e. Turn off supply and turn down output voltage.

f. Turn on supply and set desired output voltage.

NOTE

It is recommended that the crowbar be set to no less than 7% of the desired output voltage, plus one Volt, in order to avoid false tripping of the "crowbar".

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

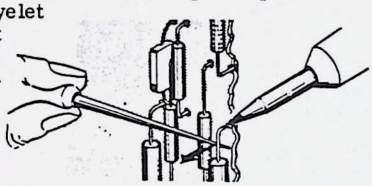
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

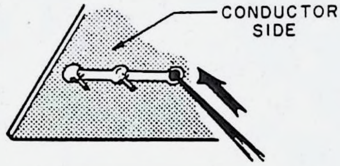
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

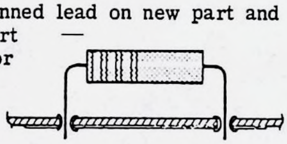
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component does not pass through an eyelet, apply heat to conductor side of board.



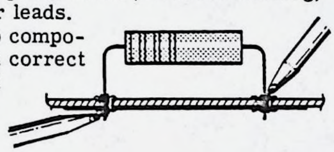
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole does not have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned lead on new part and carefully insert through eyelets or holes in board.

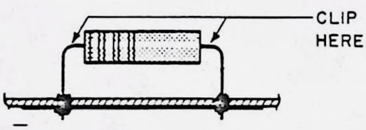


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

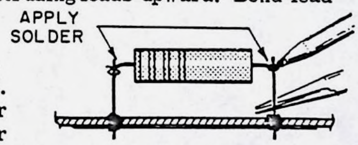


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-12. Servicing Printed Wiring Boards

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts.

6-3 Table 6-4 lists parts in alpha-numerical order of the reference designators and provides the following information:

a. Reference Designators. For abbreviations, refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ) used in the instrument; given only first time the part number is listed.

d. Manufacturer's part number.

e. Manufacturer's code number. Refer to Table 6-3 for manufacturer's name and address.

f. ⓗ Part Number.

g. Recommended spare parts quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Miscellaneous.

6-4 ORDERING INFORMATION

6-5 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses).

6-6 Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard part number.

c. Circuit reference designator.

d. Description.

6-7 To order a part not listed in Table 6-4, give a complete description of the part and include its function and location.

Table 6-1. Reference Designators

A = assembly	CR = diode
B = motor	DS = device, signaling (lamp)
C = capacitor	

Table 6-1. Reference Designators (Continued)

E = misc. electronic part	RT = thermistor
F = fuse	S = switch
J = jack	T = transformer
K = relay	V = vacuum tube, neon bulb, photocell, etc.
L = inductor	X = socket
M = meter	XF = fuseholder
P = plug	XDS = lampholder
Q = transistor	Z = network
R = resistor	

Table 6-2. Description Abbreviations

a = amperes	obd = order by description
c = carbon	p = peak
cer = ceramic	pc = printed circuit board
coef = coefficient	pf = picofarads = 10^{-12} farads
com = common	pp = peak-to-peak
comp = composition	ppm = parts per million
conn = connection	pos = position(s)
crt = cathode-ray tube	poly = polystyrene
dep = deposited	pot = potentiometer
elect = electrolytic	prv = peak reverse voltage
encap = encapsulated	rect = rectifier
f = farads	rot = rotary
fxd = fixed	rms = root-mean-square
GE = germanium	s-b = slow-blow
grd = ground(ed)	sect = section(s)
h = henries	Si = silicon
Hg = mercury	sil = silver
impg = impregnated	sl = slide
ins = insulation(ed)	td = time delay
K = kilo = 1000	TiO_2 = titanium dioxide
lin = linear taper	tog = toggle
log = logarithmic taper	tol = tolerance
mA = milli = 10^{-3}	trim = trimmer
M = megohms	twt = traveling wave tube
ma = milliamperes	var = variable
μ = micro = 10^{-6}	w/ = with
mfr = manufacturer	W = watts
mtg = mounting	w/o = without
my = mylar	cmo = cabinet mount only
NC = normally closed	
Ne = neon	
NO = normally open	

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co.	New York, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Division	
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Commercial Receiving Tube and Semiconductor Div.	Somerville, N.J.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell-Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04713	Motorola, Inc., Semiconductor Products Division	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06486	North American Electronics, Inc.	Lynn, Mass.
06540	Amathom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Nuclear Corp. of America, Inc., U.S. Semcor Div.	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Semiconductor Div. of Fairchild Camera and Instrument Corp.	Mountain View, Calif.
07387	Birtcher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Products Inc. Mountain View Operations of Sylvania Electronic Systems	Mountain View, Calif.
07716	I. R. C. Inc.	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company	Sun Valley, Calif.
08730	Vemaline Products Co.	Franklin Lakes, N.J.
08863	Nylomatic Corp.	Morrisville, Pa.
09182	Hewlett-Packard Co., Harrison Division	Berkeley Heights, N.J.
09353	C & K Components	Newton, Mass.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11502	IRC Inc.	Boone, N.C.
11711	General Instrument Corp., Semiconductor Prod. Group, Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co., Inc.	Camden, N.J.
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co.	Dover, N.H.
14493	Hewlett-Packard Co., Loveland Division	Loveland, Colo.
14655	Cornell-Dubilier Elec. Corp.	Newark, N.J.
14936	General Instrument Corp., Semiconductor Prod. Group, Semiconductor Div.	Hicksville, N.Y.
15909	Daven Div. of Thos. Edison Industries. Mc Graw Edison Co.	Livingston, N.J.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17545	Atlantic Semiconductors, Inc.	Asbury Park, N.J.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
17803	Fairchild	Mountainview, Calif.
19315	The Bendix Corp., Eclipse Pioneer Div.	Teterboro, N.J.
19701	Electra Mfg. Co.	Independence, Kan.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp., Linde Div., Kemet Dept.	Mountain View, Calif.
22767	ITT Semiconductors, A Division of International Telephone & Telegraph Corp.	Palo Alto, Calif.
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26982	Dynacool Mfg. Co. Inc	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	G. E., Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Mfg. Co., Microwave and Power Tube Div.	Waltham, Mass.
55026	Simpson Electric Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
70563	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71400	Bussmann Mfg. Div. of Mc Graw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Elkhart, Ind.
71468	I. T. T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Centralab Div. of Globe Union, Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71707	Coto-Coil	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72619	Dialight Corporation	Brooklyn, N.Y.

CODE NO.	MANUFACTURER	ADDRESS
72699	General Instrument Corp., Capacitor Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp. of America	Union, N.J.
72982	Erie Technological Products, Inc.	Erie, Pa.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Components Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Products, Inc.	Chicago, Ill.
73978	Hardwick Hindle Co., Memcor Components Div.	Huntington, Ind.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Harvey Hubbel, Inc.	Bridgeport, Conn.
74868	FXR Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75183	Howard B. Jones Div., of Cinch Mfg. Corp. (Use 71785)	New York, N.Y.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Cinch	City of Industry, Calif.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., Bendix-Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry, Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronics, Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Div. of Illinois Tool Works	Elgin, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Co., Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
79307	Whitehead Metal Products Co., Inc.	New York, N.Y.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries, Inc.	Racine, Wis.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co., Inc.	New York, N.Y.
82219	Sylvania Electric Products, Inc., Electronic Tube Division	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp., Electronic Components Div.	Plainfield, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	Radio Corp. of America, Electronic Components & Devices Div.	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco Industries Co.	Anaheim, Calif.
87216	Philco Corp. (Lansdale Div.)	Lansdale, Pa.

CODE NO.	MANUFACTURER	ADDRESS
87585	Stockwell Rubber Co., Inc.	Philadelphia, Pa.
87929	B. M. Tower Co., Inc.	Bridgeport, Conn.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell, Inc., Micro Switch Div.	Freeport, Ill.
93332	Sylvania Electric Prod., Inc., Semiconductor Prod. Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	
94144	Raytheon Co., Components Div., Industrial Components Operation	Mansfield, Ohio
94154	Tung-Sol Electric, Inc.	Quincy, Mass.
94222	South Chester Corp.	Newark, N.J.
94310	Tru-Ohm Products, Memcor Components Div.	Chester, Pa.
95263	Leecraft Mfg. Co., Inc.	Huntington, Ind. Long Island City, N.Y.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Elect.	Franklin, Ind.
96791	Amphenol Controls Div. of Amphenol-Borg Electronics Corp.	Janesville, Wis.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

THE FOLLOWING H-P VENDORS HAVE NO NUMBERS ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000	Cooltron	Oakland, Calif.
00000	Plastic Ware Co.	Brooklyn, N.Y.

Table 6-4. Replaceable Parts

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
C1	fxd, elect 5μf 50Vdc	3	30D505G050BB2	56289	0180-0301	1
C2, 4, 8, 14, 21, 23, 24, 30, 31	NOT ASSIGNED	-	-	-	-	-
C3	fxd, mylar .1μf 200Vdc	3	192P10492	56289	0160-0168	1
C5	fxd, mylar .001μf 200Vdc	1	192P10292	56289	0160-0153	1
C6, 7	fxd, mylar .01μf 200Vdc	2	192P10392	56289	0160-0161	1
C9	fxd, elect 4.7μf 35Vdc	1	150D475X9035B2	56289	0180-0100	1
C10	fxd, elect 100μf 50Vdc	1	obd	09182	0180-1852	1
C11	fxd, ceramic .05μf 500Vdc	1	33C17A	56289	0150-0052	1
C12	fxd, elect 325μf 35Vdc	1	obd	09182	0180-0332	1
C13	fxd, elect 40,000μf 50Vdc	1	obd	09182	0180-1931	1
C15	fxd, elect 1μf 35Vdc	1	150D105X9035A2	56289	0180-0291	1
C16, 17	fxd, elect 5μf 50Vdc		30D505G050BB2	56289	0180-0301	
C18	fxd, mylar .22μf 80V	1	192P2249R8	56289	0160-2453	1
C19	fxd, elect 15μf 50Vdc	1	150D156X0050R2	56289	0180-1834	1
C20	fxd, elect 5000μf 45Vdc	1	obd	09182	0180-1919	1
C22	fxd, elect 20μf 50Vdc	1	30D206G050CC2	56289	0180-0049	1
C25, 26	fxd, paper .047μf 600V	3	160P47396	56289	0160-0005	1
C27	fxd, paper .47μf 600V	1	161P47406	56289	0160-2464	1
C28	fxd, paper .047μf 600V		160P47396	56289	0160-0005	
C29	fxd, paper .1μf 400V	1	160P10494	56289	0160-0013	1
C32, 33	fxd, mylar .1μf 200Vdc		192P10492	56289	0160-0168	
CR1-5	Rect. si. 200prv	27	1N485B	93332	1901-0033	10
CR6, 7, 16-19, 29, 35, 41, 42, 48,49,53,54	NOT ASSIGNED	-	-	-	-	-
CR8	3-Junction Stabistor	1	-	09182	1901-0460	1
CR9	Rect. si. 200prv		1N485B	93332	1901-0033	
CR10	Rect. si. 1A 200prv	4	1N5059	03508	1901-0327	4
CR11	Rect. si. 20A 50prv	2	A40F	03508	1901-0323	2
CR12-14	Rect. si. 1A 200prv		1N5059	03508	1901-0327	
CR15	Rect. si. 500mA 200prv	1	1N3253	02735	1901-0389	1
CR20	Rect. si. 200prv		1N485B	93332	1901-0033	
CR21	Rect. si. 40A 100prv	2	1N1184AR	02577	1901-0318	2
CR22, 23	Rect. si. 40A 100prv	2	1N1184A	02577	1901-0317	2
CR24	Rect. si. 40A 100prv		1N1184AR	02577	1901-0318	
CR25, 26	SCR 400prv 35A	3	obd	09182	1884-0058	3
CR27,28,30-33	Rect. si. 200prv		1N485B	93332	1901-0033	
CR34	Rect. si. 20A 50prv		A40F	03508	1901-0323	
CR36	Diode, si. Stab. 2.4V 100mA	1	1N4830	03508	1901-0460	1
CR37-40 43-47,50	Rect. si. 200prv		1N485B	93332	1901-0033	
CR51, 52	Rect. si. 15prv 400mW	2	1N4828	03508	1901-0461	2
CR55	Rect. si. 200prv		1N485B	93332	1901-0033	
CR56	Rect. si. 40A 50prv	1	1N1183A	02577	1901-0315	1
CR57	SCR 400prv 35A		obd	09182	1884-0058	
CR58-60	Rect. si. 200prv		1N485B	93332	1901-0033	
DS1	Indicator Light - neon	1	599-124	72765	1450-0048	1
DS2	Indicator Light	1	MCL-83-1738	07137	~~1450-0306~~ 1450-0572	1
F1, 2	Fuse Cartridge, 10A 250V	2	314.010	75915	2110-0051	10

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
L1	Filter, Line	1	obd	09182	5080-7123	1
Q1, 2	SS NPN diff. Amp si.	2	2N4045	61637	1854-0221	2
Q3	Power NPN si.	1	40250	02735	1854-0224	1
Q4	PNP si.	1	40362	02735	1853-0041	1
Q5	SS PNP si.	5	2N2907A	04713	1853-0099	5
Q6, 7	Power NPN si. (Selected)	2	obd	09182	1854-0225	2
Q8	SS PNP si.		2N2907A	04713	1853-0099	
Q9	SS NPN si. (Selected)	5	obd	09182	1854-0071	5
Q10	SS PNP si.		2N2907A	04713	1853-0099	
Q11	SS NPN si. (Selected)		obd	09182	1854-0071	
Q12	SS PNP si.		2N2907A	04713	1853-0099	
Q13	SS NPN si. (Selected)		obd	09182	1854-0071	
Q14-17, 20, 21, 23	NOT ASSIGNED	-	-	-	-	-
Q18	SS NPN si.	2	2N3417	03508	1854-0087	2
Q19	SS NPN si. (Selected)		obd	09182	1854-0071	
Q22	SS PNP si.		2N2907A	04713	1853-0099	
Q24	SS NPN si. (Selected)		obd	09182	1854-0071	
Q25	SS NPN si.		2N3417	03508	1854-0087	
R1	fxd, ww 1KΩ ±5% 3W	1	242E1025	56289	0813-0001	1
R2	fxd, met. film 6.2KΩ ±1% 1/8W	3	CEA T-O obd	07716	0698-5087	1
R3	fxd, met. film 15KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0446	1
R4	fxd, met. film 20KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0449	1
R5	fxd, met. film 1.5KΩ ±1% 1/8W	4	CEA T-O obd	07716	0757-0427	1
R6	fxd, comp 360KΩ ±5% ½W	2	EB-3645	01121	0686-3645	1
R7	fxd, met. film 61.9KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0460	1
R8	fxd, comp 560KΩ ±5% ½W	2	EB-5645	01121	0686-5645	1
R9	fxd, ww 600Ω ±5% 5W	1	243E6015	56289	0811-1860	1
R10	var. ww 10KΩ ±5% 2W	2	obd	09182	2100-1854	1
R11	var. ww 50Ω ±10% 2W	1	obd	09182	2100-1858	1
R12	fxd, ww 680Ω ±5% 5W	1	243E6815	56289	0811-2099	1
R13	fxd, comp (Selected) ½W	2	Type EB obd	01121		1
R14	fxd, comp 3.3Ω ±5% ½W	1	EB-33G5	01121	0686-0335	1
R15	fxd, comp 3.3MΩ ±5% ½W	1	EB-3355	01121	0686-3355	1
R16	var. ww 1KΩ ±5% 2W	1	obd	09182	2100-1847	1
R17	var. ww 100Ω ±5% 2W	1	obd	09182	2100-1987	1
R18	fxd, ww 14KΩ ±3% 2W	1	222E14K00H	56289		1
R19	fxd, comp (Selected) ½W		Type EB obd	01121		
R20	fxd, met. film 1KΩ ±1% ¼W	1	CEB T-O obd	07716	0757-0338	1
R21	fxd, comp 1KΩ ±5% ½W	2	EB-1025	01121	0686-1025	1
R22, 23	fxd, met. film 6.2KΩ ±1% 1/8W		CEA T-O obd	07716	0698-5087	
R24	fxd, met. film 4.75KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0437	1
R25	fxd, comp 360KΩ ±5% ½W		EB-3645	01121	0686-3645	
R26	fxd, met. film 1.5KΩ ±1% 1/8W		CEA T-O obd	07716	0757-0427	
R27	fxd, ww .05Ω ±5% 10W	2	HMAL-11	73978	0811-1887	1
R28	fxd, comp 560KΩ ±5% ½W		EB-5645	01121	0686-5645	
R29, 34, 39, 44, 49, 55, 80-82, 85, 88, 89, 92, 93, 95, 100, 101	NOT ASSIGNED	-	-	-	-	-
R30	var. ww 5KΩ ±5% 2W	3	110-F4 obd	11236	2100-1824	1
R31	fxd, comp 1KΩ ±5% ½W		EB-1025	01121	0686-1025	
R32	fxd, ww .05Ω ±5% 10W		HMAL-11	73978	0811-1887	

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
R33	fxd, comp 330Ω ±5% $\frac{1}{2}$W	1	EB-3315	01121	0686-3315	1
R35	fxd, met. film 1KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0280	1
R36	fxd, met. film 1.5KΩ ±1% 1/8W		CEA T-O obd	07716	0757-0427	
R37	fxd, comp 560Ω ±1% $\frac{1}{4}$W	1	CEB T-O obd	07716	0698-5146	1
R38	fxd, comp 10KΩ ±5% $\frac{1}{2}$W	3	EB-1035	01121	0686-1035	1
R40	fxd, comp 33KΩ ±5% $\frac{1}{2}$W	1	EB-3335	01121	0686-3335	1
R41	fxd, met. film 12KΩ ±1% 1/8W	1	CEA T-O obd	07716	0698-5088	1
R42	fxd, met. film 6.81KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0439	1
R43	fxd, met. film 510Ω ±1% $\frac{1}{4}$W	1	CEB T-O obd	07716	0698-5145	1
R45	fxd, comp 5.1KΩ ±5% $\frac{1}{2}$W	2	EB-5125	01121	0686-5125	1
R46	fxd, comp 100KΩ ±5% $\frac{1}{2}$W	3	EB-1045	01121	0686-1045	1
R47	fxd, comp 360Ω ±5% 1W	1	GB-3615	01121	0689-3615	1
R48	fxd, met. ox. 200Ω ±5% 2W	1	C42S obd	16299	0698-3627	1
R50	fxd, comp 390Ω ±5% $\frac{1}{2}$W	1	EB-3915	01121	0686-3915	1
R51	fxd, comp 30KΩ ±5% $\frac{1}{2}$W	1	EB-3035	01121	0686-3035	1
R52	fxd, comp 22KΩ ±5% $\frac{1}{2}$W	1	EB-2235	01121	0686-2235	1
R53	fxd, comp 10Ω ±5% $\frac{1}{2}$W	1	EB-1005	01121	0686-1005	1
R54	Cupron .05Ω ±20ppm	1	obd	09182	06267-80001	1
R56	var. ww 5KΩ ±5% 2W		110-F4 obd	11236	2100-1824	
R57	fxd, met. film 47.5KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0457	1
R58, 59	fxd, comp 100Ω ±5% $\frac{1}{2}$W	4	EB-1015	01121	0686-1015	1
R60	fxd, comp 3KΩ ±5% $\frac{1}{2}$W	1	EB-3025	01121	0686-3025	1
R61	fxd, ww 135Ω ±5% 3W	1	Type 242E obd	56289	0812-0112	1
R62	fxd, met. film 471Ω ±1% 1/8W	1	CEA T-O obd	07716	0698-5514	1
R63	var. ww 250Ω ±20% 1.5W	1		09182	2100-0439	1
R64	fxd, met. film 7.5KΩ ±1% 1/8W	1	CEA T-O obd	07716	0757-0440	1
R65	fxd, met. film 5.49KΩ ±1% 1/8W	1	CEA T-O obd	07716	0698-3382	1
R66	fxd, met. film 100Ω ±1% 1/8W	1	CEA T-O obd	07716	0757-0401	1
R67	fxd, ww 400Ω ±5% 10W	1	247E4015	56289	0811-0942	1
R68	fxd, ww 220Ω ±5% 2W	1	Type BWH obd	07716	0811-1763	1
R69	fxd, comp 22Ω ±5% $\frac{1}{2}$W	4	EB-2205	01121	0686-2205	1
R70	fxd, ww 1.5KΩ ±5% 2W	1	C42S obd	16299	0698-3338	1
R71	fxd, comp 1.8KΩ ±5% $\frac{1}{2}$W	1	EB-1825	01121	0686-1825	1
R72	fxd, comp 9.1KΩ ±5% $\frac{1}{2}$W	1	EB-9125	01121	0686-9125	1
R73	fxd, comp 100KΩ ±5% $\frac{1}{2}$W		EB-1045	01121	0686-1045	
R74	fxd, comp 4.3KΩ ±5% $\frac{1}{2}$W	1	EB-4325	01121	0686-4325	1
R75	var. ww 5KΩ ±5% 2W		110-F4 obd	11236	2100-1824	
R76	fxd, comp 390KΩ ±5% $\frac{1}{2}$W	1	EB-3945	01121	0686-3945	1
R77	fxd, comp 4.7Ω ±5% $\frac{1}{2}$W	2	EB-47G5	01121	0698-0001	1
R78	fxd, comp 510Ω ±5% $\frac{1}{2}$W	2	EB-5115	01121	0686-5115	1
R79	fxd, comp 2.4KΩ ±5% $\frac{1}{2}$W	1	EB-2425	01121	0686-2425	1
R83, 84	fxd, comp 22Ω ±5% $\frac{1}{2}$W		EB-2205	01121	0686-2205	
R86	fxd, comp 100KΩ ±5% $\frac{1}{2}$W		EB-1045	01121	0686-1045	
R87	fxd, comp 3.3KΩ ±5% $\frac{1}{2}$W	1	EB-3325	01121	0686-3325	1
R90	fxd, comp 180KΩ ±5% $\frac{1}{2}$W	1	EB-1845	01121	0686-1845	1
R91	fxd, comp 15KΩ ±5% $\frac{1}{2}$W	1	EB-1535	01121	0686-1535	1
R94	fxd, comp 10KΩ ±5% $\frac{1}{2}$W		EB-1035	01121	0686-1035	
R96	fxd, met. ox. 560Ω ±5% 2W	1	C42S obd	16299	0764-0015	1
R97	fxd, comp 5.1KΩ ±5% $\frac{1}{2}$W		EB-5125	01121	0686-5125	
R98	fxd, comp 270Ω ±5% $\frac{1}{2}$W	1	EB-2715	01121	0686-2715	1
R99	fxd, comp 100Ω ±5% $\frac{1}{2}$W		EB-1015	01121	0686-1015	
R102	fxd, ww 0.125Ω ±10% 5W	1	CWS-2 obd	91637	0811-1846	1
R103	fxd, comp 100Ω ±5% $\frac{1}{2}$W		EB-1015	01121	0686-1015	
R104	fxd, ww 150Ω ±5% 5W	1	243E1515	56289	0811-1217	1
R105	fxd, comp 22Ω ±5% $\frac{1}{2}$W		EB-2205	01121	0686-2205	
R106	fxd, met. film 470Ω ±1% $\frac{1}{4}$W	1	CEB T-O obd	07716	0698-3506	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
R107	fxd, comp 510Ω ±5% ½W		EB-5115	01121	0686-5115	
R108	fxd, met. film 1.5KΩ ±1% 1/8W		CEA T-O obd	07716	0757-0427	
R109	var. ww 10KΩ ±5% 2W		obd	09182	2100-1854	
R110	fxd, comp 200KΩ ±5% ½W	1	EB-2045	01121	0686-2045	1
R111	fxd, comp 10KΩ ±5% ½W		EB-1035	01121	0686-1035	
R112	fxd, comp 4.7Ω ±5% ½W		EB-47G5	01121	0698-0001	
R113	fxd, comp 3.9KΩ ±5% ½W	1	EB-3925	01121	0686-3925	1
R114	fxd, comp 120Ω ±5% ½W	1	EB-1215	01121	0686-1215	1
S1	Switch, Toggle, DPST	1	2GK50-73XSV1	73559	3101-0946	1
T1	Transformer, Power	1	obd	09182	06267-80091	1
T2	Transformer, Bias	1	obd	09182	9100-2193	1
T3, 4	Transformer, Pulse	2	obd	09182	5080-7122	1
VR1, 2	Diode, zener 6.2V 250mW	2	1N825	04713	1902-1221	2
VR3, 4	Diode, zener 4.22V 400mW	2	1N749	04713	1902-3070	2
VR5	Diode, zener 6.19V 400mW	1	1N753	04713	1902-0049	1
VR6, 7	Diode, zener 2.37V 400mW	2	1N4370	04713	1902-3002	2
	MISCELLANEOUS					
	Chassis Assembly, Includes Sides and Tray Riveted	1	obd	09182	5060-6156	
	Chassis, Internal Tray	1	obd	09182	5000-6210	
	Chassis, Left Side	1	obd	09182	5000-6211	
	Chassis, Right Side	1	obd	09182	5000-6216	
	Cover	2	obd	09182	5000-6212	
	Panel, Front	1	obd	09182	06267-60001	
	Chassis, Rear	1	obd	09182	5020-5739	
	Heat Sink, Rear Chassis	2	obd	09182	5020-5740	
	Printed Circuit Board, Blank	1	obd	09182	5020-5721	
	P.C. Board, Includes Components	1	obd	09182	06267-60020	
	Clamp, C13	1	obd	09182	06267-00001	
	Bus Bar, C13 and C14	2	obd	09182	5000-6038	
	Heat Sink, CR25 and CR26	1	obd	09182	5020-5724	
	Brackets for Heat Sink 5020-5724	2	obd	09182	5000-6214	
	Protective Cover, Printed Board Top	1	obd	09182	5000-6215	
	Protective Cover, P.B. Bottom	1	obd	09182	5020-5726	
	Handles	2	obd	09182	5020-5715	
	Barrier Strip, Lower	1	601 YSY-6	75382	0360-1224	1
	Barrier Strip, Upper	1	obd	75382	0360-1237	1
	Jumper, Lower Barrier Strip	1	601 J	75382	0360-1279	1
	Jumper, Upper Barrier Strip	4	422-13-11-013	71785	0360-1143	1
	Knob, Front Panel	4	obd	09182	0370-0084	1
	5 Way Binding Post, Maroon	1	obd	09182	1510-0040	1
	5 Way Binding Post, Black	2	obd	09182	1510-0039	1
	Spring, Meter	8	obd	09182	1460-0256	2
	Voltmeter, 0-50V	1	obd	09182	1120-1173	1
	Ammeter, 0-12A	1	obd	09182	1120-1176	1
	Bezel, Meter	2	obd	09182	4040-0296	1
	Line Cord	1	obd	70903	8120-0852	1
	Strain Relief Bushing, Line Cord	1	SR6-P34	28520	0400-0098	1
	Serial I.D. Plate	1	obd	09182	7120-1541	1
	Guide, Printed Board, Plastic	2	obd	09182	5040-0601	1
	Clamp, C20	1	4586-2B	56289	0180-0078	1
	Fuseholder	2	342014	75915	1400-0084	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
	Hex Nut, Fuseholder	2	90312	09182	2950-0038	1
	Lockwasher, Fuseholder	2	obd	09182	2190-0715	1
	Flat Neoprene Washer, Fuseholder	2	901-2	09182	1400-0090	1
	Lockwasher, Fuseholder	2	1224-08	09182	2190-0037	1
	Shoulder Washer, Heat Sink Standoff	2	obd	09182	2190-0490	1
	Shoulder Washer, Heat Sink, CR25 and CR26	4	obd	09182	0340-0172	1
	Component Clip	1	obd	09182	1400-0321	1
	Grommet, 5/8" Dia.	4	1661	73734	0400-0062	1
	Grommet, 7/8" Dia.	2	3020	82099	0400-0063	1
	Insulator, Q3, Q6, Q7 screws	6	obd	09182	0340-0168	6
	Insulator, Q3, CR11, CR34 pins	3	obd	09182	0340-0169	3
	Insulator, Q6, Q7 pins	4	obd	09182	0340-0166	4
	Insulator, Mica, Q3	1	obd	09182	0340-0180	1
	Insulator, Mica, Q6, Q7	2	obd	09182	0340-0181	2
	Insulator, CR26, Flat, Top	1	H4021	61637	0340-0175	1
	Insulator, CR26 pin	1	obd	09182	0340-0171	1
	Shoulder Washer, CR21 thru CR24, and CR26	5	obd	09182	2190-0898	5
	Insulator, Mica, CR21 thru CR24, CR11, and CR34	6	obd	09182	2190-0710	6
	Fastener, DS1, DS2	2	C17373-012-24B	89032	0510-0123	2
	Bushing, Potentiometer R109	1	obd	09182	1410-0052	1
	Nut, Hexagon, R109	1	obd	09182	2950-0034	1
	Spacer, Hexagon, SCR Heat Sink	4	#6 x 3/8 obd	09182	0380-0183	1
	Standoff, Hexagon, SCR Heat Sink	2	8-32 x 1/2 obd	09182	0380-0136	1
	Standoff, Sensing Resistor R54	2	6-32 x 1/2 obd	09182	0380-0093	1
	Insulated Terminal, SCR Heat Sink	1	7A1-A6	92825	0360-1449	1
	Cable Clamp, 3/8 I. D.	1	obd	09182	1400-0332	1
	Cable Clamp, 1/4 I. D.	2	obd	09182	1400-0330	1
	Ground Lug, Chassis	1	#6 Int. obd	09182	-	-
	Ground Lug, Standoff	2	#8 Int. obd	09182	-	-
	Ground Lug, CR21 thru CR24	4	#1/4 Int. obd	09182	-	-
	Carton	1	obd	09182	9211-0856	-
	Floater Pad	2	obd	09182	9220-1225	-
	Standoff, Swage	2	obd	09182	0380-0391	-
	OPTION 05: 50Hz AC Input					
R76	fxd, comp 750KΩ ±5% ½W	1	EB-7545	01121	0686-7545	1
R78	fxd, comp 270Ω ±5% ½W	1	EB-2715	01121	0686-2715	1
	OPTION 07: 10-Turn Voltage Control					
R10	var. ww 10KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1866	1
	Knob, R10, Black	1	obd	09182	0370-0137	1

REF. DESIG.	DESCRIPTION	TQ	MFR. PART NO.	MFR. CODE	hp PART NO.	RS
	OPTION 08: 10-Turn Current Control					
R16	var. ww 1KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1864	1
	Knob, R16, Black	1	obd	09182	0370-0137	1
	OPTION 09: 10-Turn Voltage & Current Controls					
R10	var. ww 10KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1866	1
R16	var. ww 1KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1864	1
	Knob, R10 and R16, Black	2	obd	09182	0370-0137	1
	OPTION 10: Chassis Slides					
	Slides	1	SS-168NT20-21	83508	1490-0872	1
	OPTION 13: 3-Digit Decadial Voltage Control					
R10	var. ww 10KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1866	1
	Knob, R10, Black	1	obd	09182	0370-0137	1
	3-Digit Decadial	1	RD-411	07716	1140-0020	1
	OPTION 14: 3-Digit Decadial Current Control					
R16	var. ww 1KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1864	1
	Knob, R16, Black	1	obd	09182	0370-0137	1
	3-Digit Decadial	1	RD-411	07716	1140-0020	1
	OPTION 15: 3-Digit Decadial Voltage & Current Controls					
R10	var. ww 10KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1866	1
R16	var. ww 1KΩ ±5% 10-Turn 2W	1	obd	09182	2100-1864	1
	Knob, R10 and R16, Black	2	obd	09182	0370-0137	1
	3-Digit Decadial	2	RD-411	07716	1140-0020	1

SECTION VII
CIRCUIT DIAGRAMS

This section contains the circuit diagrams necessary for the operation and maintenance of this power supply. Included are:

a. Component Location Diagrams, Figures 7-1 and 7-2 show the physical location and reference designators of parts mounted on the printed wiring board and chassis.

b. Schematic Diagram, Figure 7-3 illustrates the circuitry for the entire power supply. Voltages are given adjacent to test points, identified by encircled numbers on the schematic and printed wiring board.

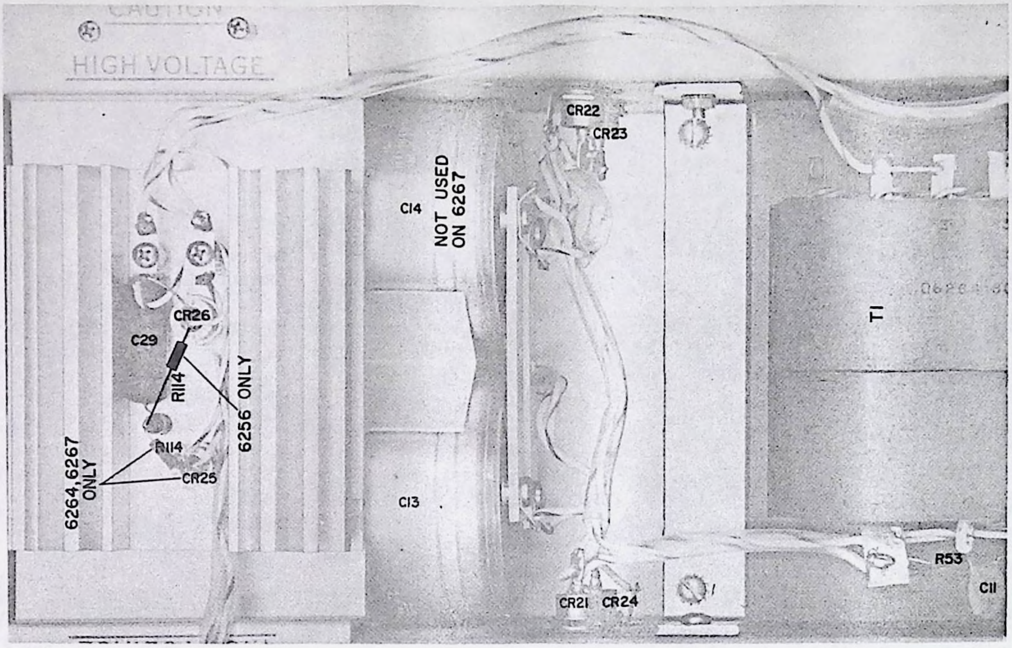
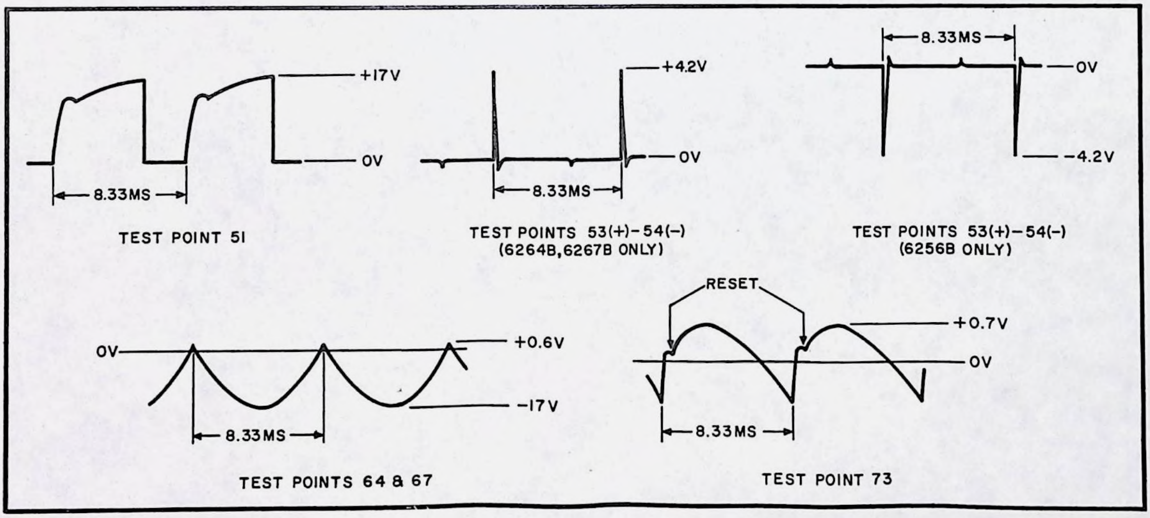


Figure 7-1. Main Chassis,
Component Location Diagram



NOTES:

1. ALL WAVEFORMS TAKEN WITH NOMINAL INPUT AT MAXIMUM RATED OUTPUT VOLTAGE AND NO LOAD CONNECTED. AMPLITUDES ARE TYPICAL ±10%.
2. OSCILLOSCOPE DC COUPLED AND REFERENCED TO INBOARD SIDE OF CURRENT SAMPLING RESISTOR UNLESS OTHERWISE INDICATED.
3. WAVEFORMS NOT DRAWN TO SCALE.

Figure 7-2. Preregulator
Control Circuit Waveforms

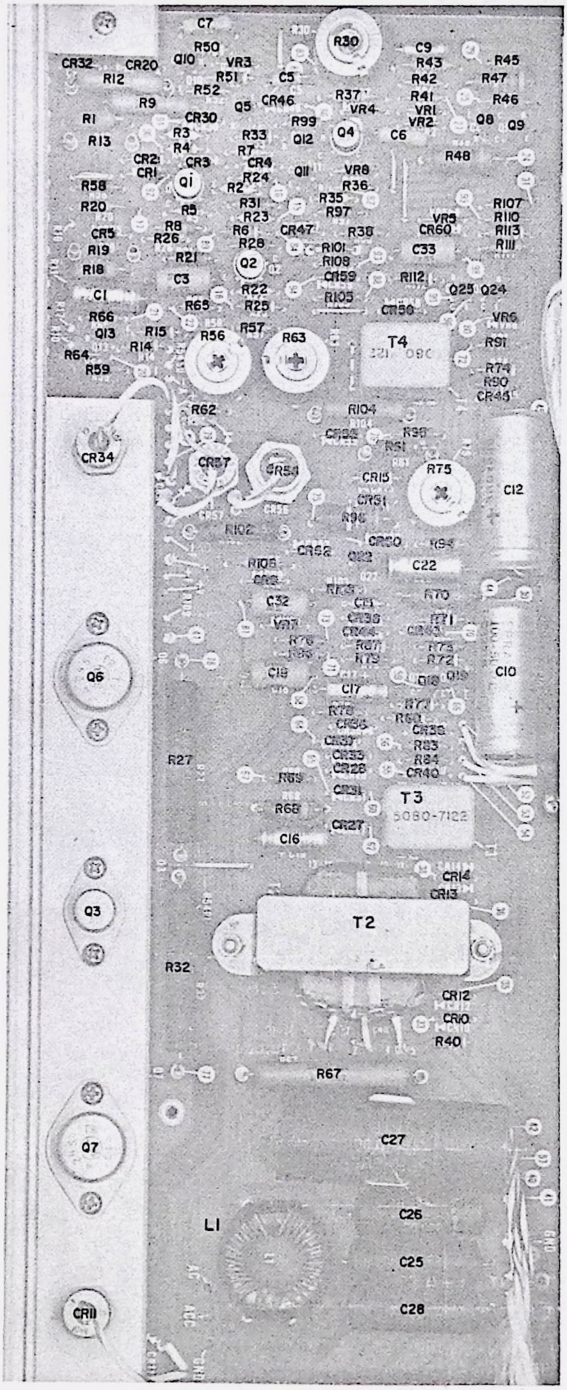
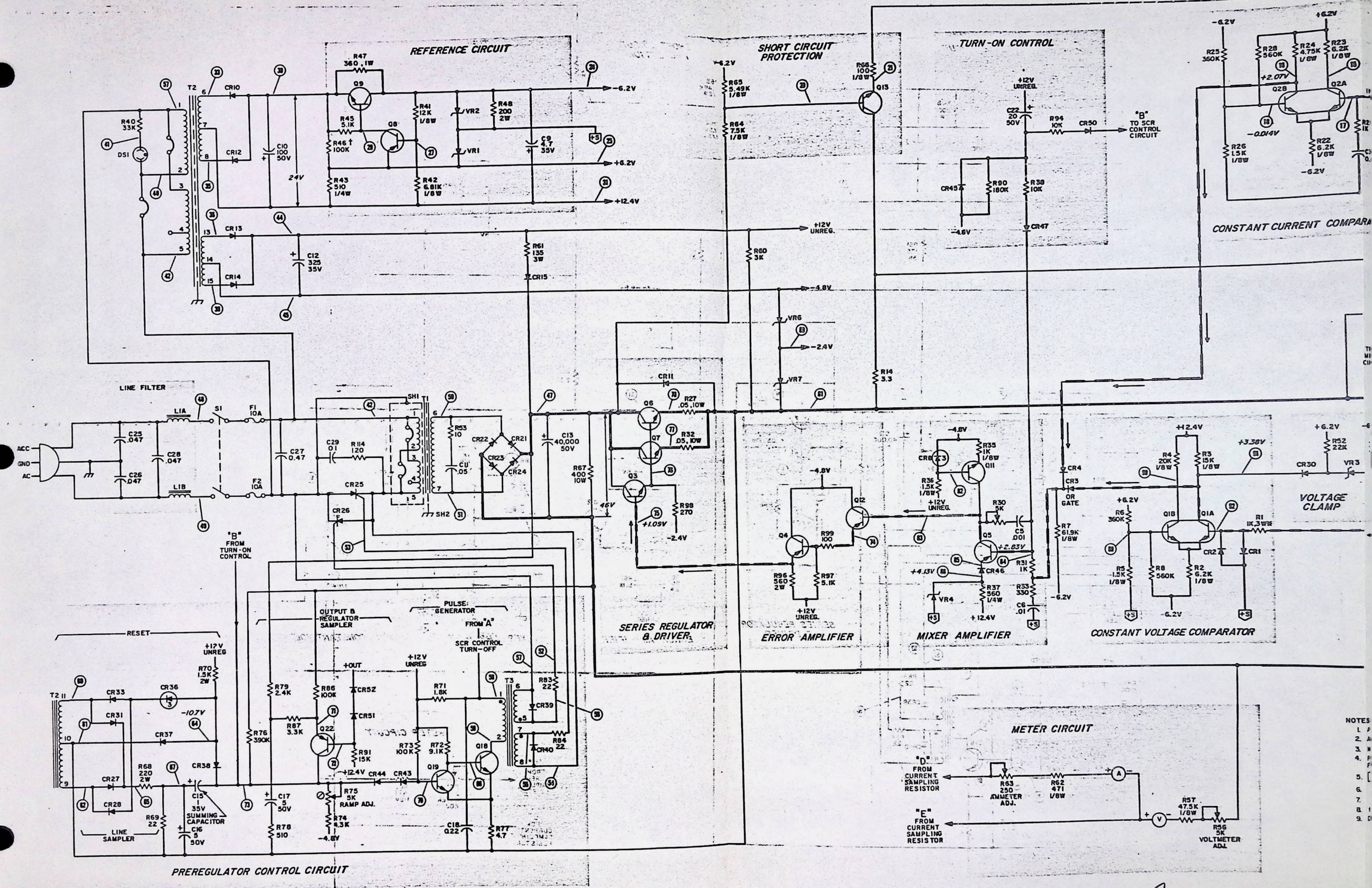


Figure 7-3. Printed Circuit Board
Component Location Diagram


REFERENCE CIRCUIT
SHORT CIRCUIT PROTECTION
TURN-ON CONTROL
CONSTANT CURRENT COMPARA
LINE FILTER
SERIES REGULATOR & DRIVER
ERROR AMPLIFIER
MIXER AMPLIFIER
CONSTANT VOLTAGE COMPARATOR
VOLTAGE CLAMP
RESET
LINE SAMPLER
OUTPUT & REGULATOR SAMPLER
PULSE GENERATOR
SCR CONTROL TURN-OFF
METER CIRCUIT
PREREGULATOR CONTROL CIRCUIT
"B" TO SCR CONTROL CIRCUIT
"B" FROM TURN-ON CONTROL
"D" FROM CURRENT SAMPLING RESISTOR
"E" FROM CURRENT SAMPLING RESISTOR
R63 250 AMMETER ADJ.
R56 5K VOLTMETER ADJ.
R75 5K RAMP ADJ.
C15 1 35V SUMMING CAPACITOR
NOTES

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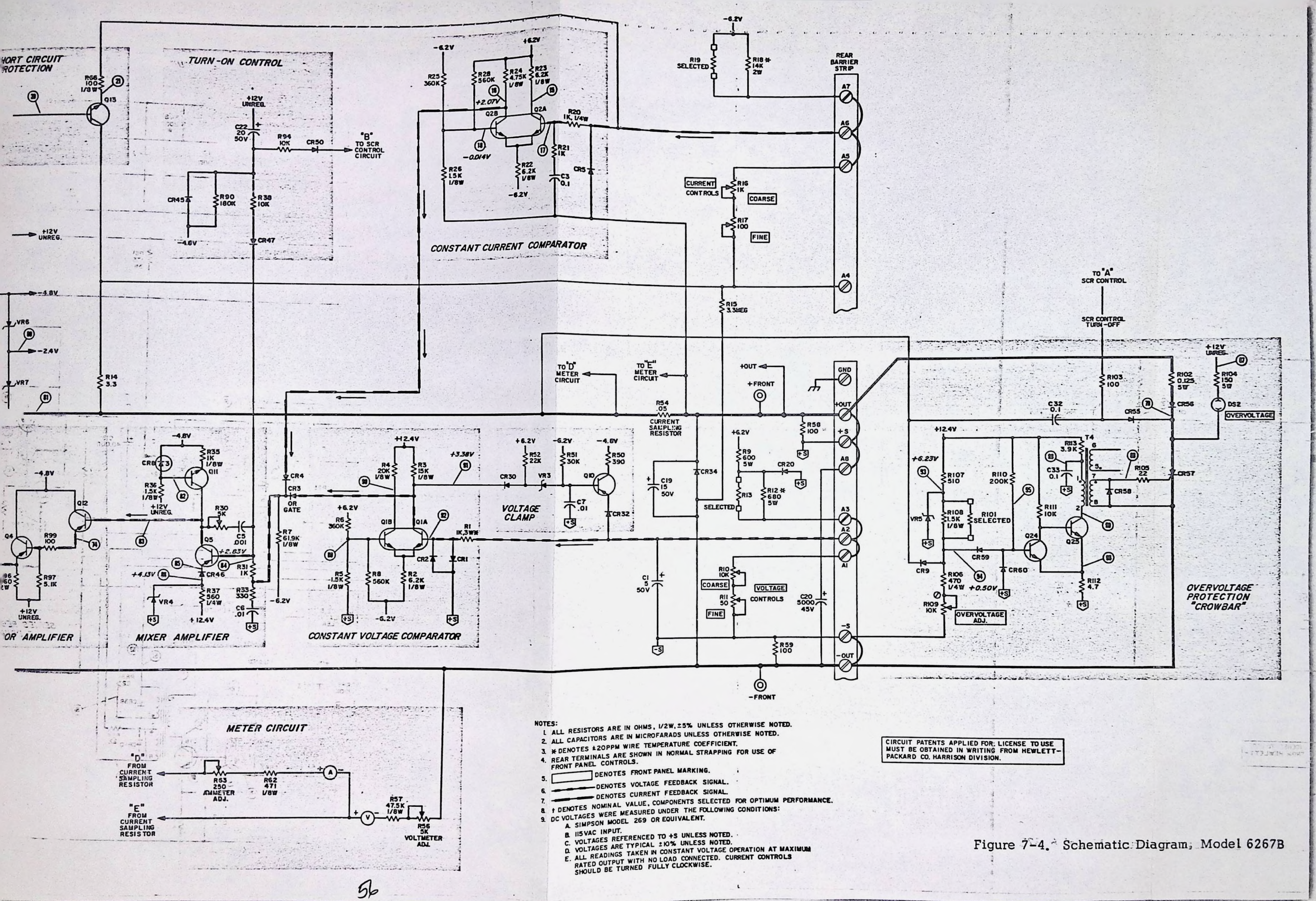

NOTES:

1. ALL RESISTORS ARE IN OHMS, 1/2W, ±5% UNLESS OTHERWISE NOTED.
2. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
3. * DENOTES ±20PPM WIRE TEMPERATURE COEFFICIENT.
4. REAR TERMINALS ARE SHOWN IN NORMAL STRAPPING FOR USE OF FRONT PANEL CONTROLS.
5. DENOTES FRONT PANEL MARKING.
6. DENOTES VOLTAGE FEEDBACK SIGNAL.
7. DENOTES CURRENT FEEDBACK SIGNAL.
8. † DENOTES NOMINAL VALUE, COMPONENTS SELECTED FOR OPTIMUM PERFORMANCE.
9. DC VOLTAGES WERE MEASURED UNDER THE FOLLOWING CONDITIONS:
   A. SIMPSON MODEL 269 OR EQUIVALENT.
   B. 115VAC INPUT.
   C. VOLTAGES REFERENCED TO +S UNLESS NOTED.
   D. VOLTAGES ARE TYPICAL ±10% UNLESS NOTED.
   E. ALL READINGS TAKEN IN CONSTANT VOLTAGE OPERATION AT MAXIMUM RATED OUTPUT WITH NO LOAD CONNECTED. CURRENT CONTROLS SHOULD BE TURNED FULLY CLOCKWISE.

CIRCUIT PATENTS APPLIED FOR; LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HEWLETT-PACKARD CO. HARRISON DIVISION.

Figure 7-4. Schematic Diagram, Model 6267B

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APPENDIX A
MANUAL BACKDATING CHANGES

Manual backdating changes describe changes necessary to adapt this manual to earlier instruments. To adapt this manual to serial numbers prior to 8G0270, inspect the following table for your serial number and then make the appropriate changes. For serial numbers 8G0301 and up, check for inclusion of a change sheet.

SERIAL		MAKE CHANGES
Prefix	Number	
8G	0161-0270	1
8G	0101-0160	1, 2

CHANGE 1: In replaceable parts table and on schematic, make the following changes:
R108: Change to 1.33KΩ ±1% $\frac{1}{4}$W, hp Part No. 0698-3134.
R109: Delete (open circuit).

CHANGE 2: In replaceable parts table and on schematic, make the following changes:
Heat Sink (Rear): hp Part No. 06264-20002.
R63: Change to 100Ω - 110Ω variable, hp Part No. 2100-0281.

MANUAL CHANGES

Model 6267B DC Power Supply
Manual Serial Number Prefix 8G

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
ALL	-	Errata
8G	0161 - 0270	1
8G	0271 - up	1, 2

ERRATA:

In Table 6-4, under Option 05, add R78, fxd comp 270Ω, ±5%, ½W, EB-2715, 01121, ⓗ Part No. 0686-2715.

On Page 3-4, Paragraph 3-32, change 2.5mA to 0.5mA.

In Figure 3-9, add a connection between the (-) terminal of the master and the (+) terminal of slave number 1; change the right hand terminal of the same master from +S to -S.

On Page 4-4, Paragraph 4-25, the text should read: "...transistor Q19 is turned off and Q18 is turned on. The conduction of Q18 allows capacitor C18 to..."

On Page 4-6, in Paragraph 4-52, change DS1 to DS2 wherever it appears.

In Figure 5-3 and 5-10, the correct value of load resistance for Model 6267B is 4Ω, 400 watt, ±5%.

On Pages 5-3 and 5-8, in Paragraphs 5-12 and 5-46, add the following note: Load regulation specifications must be measured at the rear output terminals, not at the front terminals.

On Page 5-3, Paragraph 5-13, step c should read: "...until front panel meter indicates maximum rated output voltage."

On Page 5-4, in Paragraph 5-20, the last sentence should read: "...leads connecting these terminals to the scope terminals, the scope case and the third wire of the scope line cord."

On Page 5-5, in Paragraph 5-27, the text should read: "The circuit of Figure 5-5 can also be used..."

On Page 5-7, in Paragraph 5-35, step b should read: "...until the front panel meter indicates 5 amps or the maximum rated output current, whichever is less."

On Page 5-7, in Paragraph 5-38, the text should read: "....which will result over any 1°C interval."

On Page 5-8, in Paragraph 5-45, steps b and c should read as follows:

b. Turn VOLTAGE controls fully clockwise.
c. Turn on supply and adjust CURRENT controls until front panel ammeter indicates maximum rated output current.

In Table 5-3, under Poor Load Regulation, (Constant Current), step c should read: "C19, C20, leaky."

In Step 4 of Table 5-5, the instruction should read "Check turn-off of Q5 by shorting Q13 emitter to collector."

CHANGE 1:

In Table 6-4, make the following chances:

Change "Heat-Sink, Rear Chassis" to ⓗ Part No. 5020-5740.

Change "Chassis, Rear" to ⓗ Part No. 5020-5739.

On Figure 7-3 and Table 6-4, change R63 to var. ww, 250Ω, ±20%, 1.5W, ⓗ Part No. 2100-0439.

CHANGE 2:

In the replaceable parts list and on the schematic, make the following changes:

R108: fxd, met. film 1.33KΩ ±1% 1/8W, ⓗ Part No. 0698-3134.

9-1-69

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Louisville 40223
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St. Paul 55113
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Avenida Italia 2877
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Telex: 702 Public Booth
Para Pablo Ferrando

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Hewlett-Packard de Venezuela C.A.
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Zastopstvo Hewlett-Packard
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